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# A STUDY OF THE STATE-OF-THE-ART OF INSTRUMENTATION FOR PROCESS CONTROL AND SAFETY IN LARGE-SCALE COAL GASIFICATION, LIQUEFACTION, AND FLUIDIZED-BED COMBUSTION SYSTEMS

Final Report

by

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W. W. Managan, H. B. Karplus,
and T. P. Mulcahey

Distribution Category:
Coal Conversion Demonstration
Plants (UC-89)

ANL-76-4

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January 1976



Prepared for the Assistant Administrator for Fossil Energ
U. S. Energy Research and Development Administration
under Contract E(49-18)-1740

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## ABSTRACT

A study has been carried out to determine the state-of-the-art of instrumentation which is available for process control and safety in planned demonstration and commercial scale coal gasification, liquefaction, and fluidized-bed combustion systems. The study identified available instrumentation which will perform satisfactorily in these systems and pinpointed deficiencies for which instruments must be developed. The identified deficiencies fall into the same few categories for all processes considered. These categories are presented with associated physical parameters found in the various processes studied.

Development of instruments to meet these deficiencies is recommended along with development of control valves and optimal control schemes in order to assure the possibility of automatic control of the large scale coal conversion and combustion systems.

## 1.0 SUMMARY

A study of the state-of-the-art of instrumentation for process control and safety in demonstration and commercial scale coal gasification, liquefaction, and fluidized-bed combustion plants has been carried out by Argonne National Laboratory for the U.S. Energy Research and Development Administration, Fossil Energy Division. The object of the study was to survey the current state-of-the-art in instrumentation and to identify deficiencies that will exist in the large scale coal plants unless appropriate new instruments are developed.

Much of the information for this study has been collected through contact with operating personnel at pilot and sub-pilot coal conversion and combustion plants and with engineers involved in the evaluation of these processes and the design of demonstration and commercial size versions of them. Other information has come from a study of piping and instrument diagrams for the pilot scale systems by engineers at Fluor Pioneer Inc., who evaluated the instruments shown with regard to suitability for scale-up, on the basis of their experience in the power and chemical processing industries. Other sources of information have been technical reports on the various processes.

Conclusions of the study are that, with very few exceptions, instrumentation deficiencies in all processes fall under four general headings: mass flow rate of mixed-phase process streams, on-line composition monitoring of process streams, levels of oil/water interfaces and of fluidized beds, and temperatures in reaction vessels and on vessel walls.

It is recommended that development of instruments to meet these deficiencies be started as soon as possible. The suggested development program has as its aim the commercial availability of needed instruments, compatible with the requirements of automatic controllers, when the first demonstration scale conversion plant is completed. Recommendations are also made in two areas which have been brought out as serious problems in the course of this study even though they were not within the scope of the present study. One of these is in the area of control valve development; and the other is in the area of optimal control scheme development. Development of instruments as well as development of the control valves and of the control schemes are all necessary before automatic control of the large scale processes will be possible.

## 2.0 PROBLEM INVESTIGATED

This study, carried out by Argonne National Laboratory (ANL) and funded by the Fossil Energy Division, U.S. Energy Research and Development Administration, was concerned with an evaluation of the state-of-the-art of instrumentation for process control and safety in large-scale coal gasification, liquefaction, and fluidized-bed combustion systems. The object of this study was to identify deficiencies which will exist in instrumentation for these systems unless appropriate action is taken, and to recommend a program of research, development, and technology transfer aimed at the timely commercial availability of needed instruments.

## 3.0 METHOD OF INVESTIGATION

Information for this study was gathered by ANL staff through on-site discussions with staff of coal conversion and fluidized combustion pilot plants and process development units in this country, technical discussions with engineers engaged in the design of large-scale plants, and a survey of the technical literature. A complementary study was conducted, under subcontract to ANL, by Fluor Pioneer Inc. Fluor engineers considered the instruments shown on piping and instrument diagrams for coal conversion pilot plants and made a judgement of the capability of each instrument to perform adequately under process conditions in the pilot plant and in the scale-up to commercial plant operation.

### 3.1 The Argonne National Laboratory Survey

In order to learn of instrumentation deficiencies in small scale systems planned large-scale systems based on these processes, ANL instrumentation development staff made a number of technical visits. They visited the high-Btu gasification pilot plants for the HYGAS, $CO_2$ Acceptor, and Synthane processes and consulted with engineers at C. F. Braun and Co., who are concerned with project evaluation for the high-Btu processes and design of commercial plants based on these processes. They visited liquefaction pilot plants for the COED and SRC processes as well as the bench-scale Synthoil unit and consulted with engineers at The Ralph M. Parsons Co., who are doing project evaluation for the liquefaction pilot plants and design of commercial plants. Other sources of information on needs of conversion systems were Foster Wheeler Energy Corporation and the Morgantown Energy Research Center (MERC). Fluidized-bed combustion facilities at ANL, Exxon Research and Engineering Co, and Combustion Power Co. Inc., were visited and discussions were held with ERDA-Fossil Energy staff concerned with the Pope, Evans and Robbins system. Additional information on the needs of fluidized-bed coal combustion systems came from staff at Westinghouse Research Laboratories and at Foster Wheeler. These technical visits are listed in Table I with the date of the visit and list of persons interviewed.

Each instrumentation need found during these technical visits or from a search of the technical literature was recorded on a data sheet along with information about the conditions in which the instrument would have to operate. A priority rating of low, medium, high, or very high was assigned to each need. Appendix A contains the data sheets on instrumentation needs.

### 3.2 The Fluor Pioneer Inc., Study

In order to get a different perspective on the evaluation of instrumentation currently in use in pilot plants, ANL engaged Fluor Pioneer, Inc., a Chicago-based engineering firm with many years of experience in design and consulting on all engineering aspects of the electric utility power and chemical processing industries. Fluor engineers studied in detail the piping and instrumentation diagrams for the five operational pilot plants (COED, SRC, HYGAS, $CO_2$ Acceptor, and Synthane) and evaluated each instrument shown. In cases where the instrument was being used for measurements within its capability and there was no question of scale-up, it was not considered further. Where there was doubt about the ability of the instrument to function reliably or with sufficient sensitivity and accuracy under process conditions, where scale-up was doubtful, where the parameter of interest might be better determined by another measurement, or where a measurement is needed for reliable process control and there is no appropriate instrument, the information was noted and a recommendation made. Appendix B is a report of the Fluor Pioneer study.

## 4.0 CONCLUSIONS

The findings of the ANL and Fluor Pioneer studies are in agreement. Over 90% of the instruments being used in coal conversion and fluidized combustion systems are conventional instruments which function satisfactorily and will scale-up. With few exceptions, the instrumentation deficiencies fall into four general categories: (1) Mixed phase mass flow, (2) On-line composition, (3) Level, and (4) Temperature. Within each of these categories, there are up to three rather distinct groupings within which the parameters to be measured and the associated physical conditions are similar. Very few instances have been found of available instruments that have not been tried in the coal plants or instruments under development which show promise of meeting any of these needs.

### 4.1 Evaluation of Present Instrumentation

In the Fluor Pioneer study of the piping and instrument diagrams for the COED, SRC, HYGAS, $CO_2$ Acceptor, and Synthane pilot plants, 4,569 instruments

TABLE I. Technical Visits by ANL Instrumentation Staff

| Location | Date | Persons Interviewed |
|---|---|---|
| **Conversion** | | |
| Pittsburgh Energy Research Center (Synthane, Synthoil, Hydrane) | 2-7-74 | Bert Forney, Stan Gasior, Murray Weintraub, Joe Mima |
| *COED Princeton, N. J. | 10-5-74 | Louis J. Scotti, Haig D. Terzian |
| *HYGAS Chicago, Ill. | 11-8-74 | Frank C. Schora, John W. Loeding, Jack Huebler, Bill Bair |
| *$CO_2$ Acceptor Rapid City, S.D. | 11-22-74 | Frank Fink, Irl Zuber, Chet Krcil, Marion Vardamon, David Glaser, Phil Boland, Frank Plut, Frank Batug, Terry Towers |
| C. F. Braun Co. Alhambra, Calif. | 1-31-75 | Richard Howell, Robert Stalnaker, Charles Chao |
| Pittsburgh Energy Research Center (Synthane, Synthoil) | 4-18-75 | E. O. Curtiss, Jr., Dale Mackey, Duane Runnels, Murray Weintraub |
| *SRC Ft. Lewis, Wash. | 6-11-75 | Robert Sperhac, Joseph Naylor, Andrew Danhof, Robert Custer, Russ Perrussel, David Schmalzer |
| Ralph M. Parsons Co. Pasadena, Calif. | 10-9-75 | Andrew Bela, Frank Glenn, Eugene Pastrick, George Hervey |
| **Combustion** | | |
| *Argonne National Lab. Chicago, Illinois | Continuing | Al Jonke, Ervin Carls, Walt Podolski, John Vogel, Bill Swift |
| *Exxon Research & Eng. Linden, N.J. | 8-12-75 | Dr. Ron Hoke, Melvyn Nutkis, Ray Van Sweringer |
| *Combustion Power Co. Menlo Park, Calif. | 10-10-75 | Michael O'Hagan, Gordon Wade, Rossi Jackson, Henry Wigton |
| **Instrumentation** | | |
| Morgantown Energy Research Center | 2-15-74 | Dr. William Eckard, Robert F. Stewart, L. Wayne Shuck, Neil Coates |
| Lawrence Livermore Laboratory | 2-3-75 | Jack Salisbury, Clarence Calder, Ray Cornell |
| The Foxboro Company Foxboro, Mass. | 8-13-75 | Robert Shaw, John Bernard, Charles Cooper, Cal Watson, Dr. James Vignos, Dr. Peter McCrae |

*Plants with operating experience.

were considered. Over 90% of these instruments were judged by Fluor engineers to be well-suited to their tasks and readily scaled-up, based on their experience in plant design and consulting. The remaining instruments fell into the four categories listed above in Section 4.0. A list of instruments reviewed in the Fluor Pioneer study, divided into instruments considered suitable and those considered unsuitable in scaled-up plants is included in Appendix B.

## 4.2 Deficiencies in Instrumentation

Instrumentation deficiencies found in the study are summarized in Table II. Mixed phase mass flow needs fall into three categories: dense phase solids mass flow, dilute phase solids mass flow, and dirty gas flow (entrained solids mass flow). Composition monitoring deficiencies occur for: carbon, hydrogen, oxygen, sulfur, and ash content of solids and liquids in streams and vessels; elemental components such as sulfur, metals, and alkalis in gas streams; and molecular components of gas streams. Level detection is needed for oil/water interfaces and must be improved for fluidized bed heights. Detection of temperature in the 1500 to 3000°F range with rapid response to excursions and monitoring of vessel walls and pipes for hot spots are problems that have not been solved. Appendix A contains details of the conditions where instruments are needed in the individual plants.

### 4.2.1 Mixed Phase Mass Flow Rates

Continuous monitoring of mass flow in the process streams of modern coal gasification, liquefaction, and fluidized-bed combustion systems is essential for process control. Such measurements are made difficult in process streams of solids mixed with fluids by the corrosive and abrasive nature of the streams as well as by their high temperatures and/or pressures. In addition, the velocity profile in a multicomponent flow is complex, with liquid, solid, and gas fractions flowing at different average speeds and, for the solid fraction, particle speed depending on particle size. In the case of a slurry, knowledge of total mass flow is required as well as a separate determination of the solid fraction.

Flowmeters which rely on differential pressure measurements (e.g., orifice and Venturi meters) are unsatisfactory because of plugging of the pressure taps. Flowmeters which have obstructions in the flow stream (e.g. orifice, target, turbine meters) are subject to excessive abrasion.

Mixed phase (solids mixed with fluids) mass flow rate instrumentation is the most serious instrumentation need in the pilot plants and process development units visited by ANL. Only in atmospheric fluidized-bed combustion systems is lack of instrumentation to measure another variable (bed temperature) more critical.

#### 4.2.1.1 Dense Phase Solids Mass Flow

This flow system occurs when crushed coal is slurried with oil or water for injection at high pressure into a conversion system or when solid material flows through a standleg to fall through a constriction into a vessel or into a pneumatic transport system. The solids density is limited by contact between the particles. The measurement is needed for process control with high to very high priority rating.

TABLE II. ANL Survey of Instrumentation Deficiencies[a]

| Process | Value | $P_{max}$ (psig) | $T_{max}$ (°F) | Density (lb/ft$^3$) | Composition (% = % vol) | Particle Size max(mm) |
|---|---|---|---|---|---|---|
| **Dense phase solids mass flow** | | | | | | |
| Gasification | 1-10 ft/sec | 1500 | 3000 | 25-70 | >30% char | 6 |
| Liquefaction | 1-5 ft/sec | 4500 | 2000 | 20-70 | >33% char | 3 |
| FBC | 3-4 ft/sec | 150 | 1500 | 35-45<br>∿100 | >40% char<br>∿50% alumina | 3 |
| Summary | 1-10 ft/sec | 4500 | 3000 | 25-100 | 30-50% solids | 6 |
| **Dilute phase solids mass flow** | | | | | | |
| Gasification | 3-10 ft/sec | 1500 | 1800 | 6-15 | 10-25% | 0.25 |
| Liquefaction | ∿40 ft/sec | 15-25 | 1600 | ∿1 | 1-2% | 3 |
| FBC | 3-70 ft/sec | 150 | 1500 | ∿1<br>14-60 | 1-2% char/dolo.<br>8-30% dolomite | 6 |
| Summary | 3-70 ft/sec | 1500 | 1800 | 1-60 | 1-30% solids | 6 |
| **Dirty gas flow - entrained solids mass flow** | | | | | | |
| Gasification | <10 grains/scf | 1000 | 2000 | | <1% char/ash | 0.06 |
| FBC | 0.1-2 gr/scf | 150 | 1600 | | <1% char/ash | 0.01 |
| Summary | <10 grains/scf | 4500 | 2000 | | <1% solids | 0.06 |
| **C, H, O, S, ash content of streams and vessels** | | | | | | |
| Gasification | 0.1-90% wt | 1500 | 3000 | 1-100 | char/ash/ | 6 |
| Liquefaction | 0.1-90% wt | 4500 | 2000 | 20-70 | oil/ | 3 |
| FBC | 0.1-90% wt | 150 | 1500 | 35-100 | limestone | 3 |
| Summary | 0.1-90% wt | 4500 | 3000 | 1-100 | | 6 |
| **Elements in gas streams** | | | | | | |
| Gasification - metal and S to methanation in ppm range | | | | | | |
| FBC - alkali metals to turbines in ppb range | | | | | | |
| **Molecular composition of gas streams** | | | | | | |
| Gasification | >0.1% wt | 1500 | 3000 | | $CO$, $CO_2$, $SO_2$, | |
| Liquefaction | >0.1% wt | 4500 | 2000 | | $SO_3$, $NO_x$, $CH_4$ | |
| FBC | >0.1% wt | 150 | 500 | | $HCl$, $O_2$, $H_2$, | |
| Summary | >0.1% wt | 4500 | 3000 | | $COS$, $H_2$ | |
| **Level of oil/water interface** | | | | | | |
| Conversion | | 1500 | 500 | 1.1:1.0:0.98<br>heavy oil:water:light oil | | |
| **Fluidized bed levels and densities** | | | | | | |
| Summary | 1.5-15 ft | 1500 | 3000 | | ∿50% solids | |
| **Temperatures in reactors (reducing) and combustors (oxidizing** | | | | | | |
| Summary | 1500-3000°F | 1500 | 3000 | | (rapid response) | |
| **Temperature of vessel walls (hot spots)** | | | | | | |
| Summary | >700°F | 0 | | | | |

[a]Appendix A contains details of the locations and conditions where these measurements are needed.

This need was expressed by staff of the HYGAS plant for two points in the process, $CO_2$ Acceptor for one point, BI-GAS for two, SRC for six, COED for six, Synthoil for two, and Combustion Power for one. C. F. Braun, Parsons, and Foster Wheeler also gave this as a major need.

Table II outlines conditions associated with these flow systems. The parameters given are those which are expected to be most similar in pilot scale systems and commercial scale plants. For example, the flow speed is listed rather than the mass flow rate because the mass flow rate will scale up by a factor of 100 to 1000, whereas the flow speed will probably be within a factor of 2 or 3 of that in the pilot scale system.

4.2.1.2 Dilute Phase Solids Mass Flow

This flow system usually occurs in a pneumatic transport line where crushed solids are fed into a reactor or combustor or in the dip leg of a cyclone separator, where dense phase conditions may be approached. Measurement of the flow in the cyclone dip leg is needed for monitoring of cyclone operation and is a very high priority need. Flow in pneumatic transport systems is needed for process control and has a high to very high priority. In a number of systems, flow of a given stream may be measured either in the dense phase in a standleg or in the dilute phase during pneumatic transport, but is not necessary in both places.

Dilute phase solids mass flow was given as a serious need by staff at the HYGAS plant for two points, BI-GAS for one point, COED for six (alternate measurements for the six dense phase measurement points), ANL for two, Combustion Power for three, and Exxon for two. Foster Wheeler also mentioned this as a serious need.

Conditions associated with these measurements are given in Table II. These systems range from about 1 to 30% by volume of solids and tend to have higher speeds than the dense phase flow.

4.2.1.3 Dirty Gas Flow - Entrained Solids Mass Flow

Measurement of very small particle entrainment in gas streams is extremely important for protection of turbines in a pressurized fluidized-bed combustion system. It is a very high priority need in gasification processes in the product gas stream from the gasifier cyclone both for protection of gas cleanup equipment and for materials balance.

This need was named by personnel at the $CO_2$ Acceptor plant at two locations, COED at one point, ANL at one point, Combustion Power at two points, Exxon at one point, and Pope, Evans and Robbins at one point. C. F. Braun, Parsons, Westinghouse, and Foster Wheeler gave it as a general need.

Table II gives conditions encountered where these measurements are needed. Particle sizes are generally less than a few tens of micrometers, and the loading is usually less than 10 grains per standard cubic foot of gas.

4.2.2 On-Line Composition Monitoring

The need for on-line composition monitoring for process control and environmental protection is the second highest priority item found in the study. The systems presently in use for composition determination involve sampling and have the problems inherent in sampling: uncertainty about whether the sample is representative of the process material and a time lag between the taking of the sample and completion of the analysis. In many cases, obtaining the sample and reclosing the system is made very difficult by the high pressures and temperatures and by the abrasive nature of the process material. Refer to Table II for conditions.

4.2.2.1 C, H, O, S, and Ash Content of Solids and Liquids in Streams and Vessels

The process streams where these composition measurements are needed are generally those for which solids mass flow is needed in dense phase or dilute phase (4.2.1.1 and 4.2.1.2). These are primarily streams feeding into, out of, or between conversion or combustion vessels, and the measurement is needed for control of the reaction rate within the vessel for maximum use of raw materials, optimum apportionment of products, and safety.

Five locations in the HYGAS plant were given as needing this kind of instrumentation, two in the $CO_2$ Acceptor plant, one in the BI-GAS, one in the COED, three in the SRC, two in the ANL, one in the Exxon, two in the Combustion Power, and two in the Pope, Evans and Robbins. C. F. Braun mentioned this as a general need in coal preparation for all processes.

4.2.2.2 Elements in Gas Streams

Two distinct situations occur where trace elements in gas streams must be monitored. The streams are usually the same ones listed under gasification and fluidized-bed combustion under the dirty gas flow - entrained-solids mass flow heading (4.2.1.3).

The product gas from any gasifier must be monitored for elements in the ppm range which are damaging to the methanation catalyst according to engineers at C. F. Braun. This includes S, Ni, Fe, and V.

In all pressurized fluidized-bed combustion (PFBC) systems, alkali ions in the flue gas cause severe and rapid corrosion of turbine blades. This very high priority need, cited by Westinghouse as well as staff at the PFBC systems, requires detection of Na and K ions in the ppb range.

A third, rather general need in this category is for monitoring of environmentally-harmful trace elements in effluent gases from these processes.

4.2.2.3 Molecular Composition of Gas Streams

Measurement of the molecular composition of product gas streams in conversion systems is necessary for process control, and molecular composition of flue gases is needed in both conversion and combustion systems for environmental protection. While systems in use (gas chromatographs, infrared, polarographic analyzers) can measure the concentrations of the molecules of interest, they all require cooling, drying, and filtering of the sample. They work satisfactorily only to the extent that the analyzed sample is representative of or can be related to the gas in the stream. There is generally at least a few minutes delay between sample-taking and completion of the analysis. Finally, calibration of these instruments is time-consuming, requiring a great deal of time from a trained and careful person.

In the words of an engineer at the Combustion Power FBC, there is "nothing close to being acceptable" in the area of gas analysis. This was given as a problem at the $CO_2$ Acceptor plant, COED, SRC, and as well as Combustion Power.

#### 4.2.3 Level Measurement

A high priority instrumentation lack in level measurement which occurs in a number of processes involves detection of oil/water interfaces. A more widespread need in the area of level detection is for improved instrumentation to monitor fluidized-bed heights.

##### 4.2.3.1 Level of Oil/Water Interfaces

Many of the conversion processes include a step where oil and water vapors are condensed out of a gas and collected in a large vessel for gravity separation. It is necessary to monitor the level of the oil/water interface to prevent water withdrawal through the oil tap, and vice versa. Because the oil and water densities are very similar, floats and gamma gauges do not work; and because the liquids are dirty, level glasses do not allow observation of the interface. Table II lists relevant parameters.

This is a problem at the HYGAS, COED, and SRC plants - three of the four coal conversion plants with operating experience. It is expected to be a problem at the Synthane plant.

##### 4.2.3.2 Fluidized-Bed Levels and Densities

Most gasification processes, some liquefaction processes, and, of course, all fluidized-bed combustion processes have one or more fluidized beds of crushed solids in gas. Bed levels and densities are usually inferred from measurement of differential pressure between taps with a known vertical separation, with both in the bed and with one in and one out of the bed. The system has not been modeled well enough to allow prediction of differential pressure readings for given conditions within the bed, but it is possible to find reliable correlations between readings and bed conditions by experiment on a given system. The biggest problem with the differential pressure technique of fluidized-bed level detection occurs because of plugging of the pressure taps.

This problem is considered to be of medium priority since the pressure taps can be designed to allow rodding out in the event of plugging, as has been done at the $CO_2$ Acceptor plant. However, the development of a differential pressure technique which is not subject to plugging or the development of a completely different method for monitoring the bed heights would be highly desirable according to staff at HYGAS, COED, ANL, Exxon, Combustion Power, and Foster Wheeler. The SRC process has no fluidized beds, but uses the same differential pressure technique to measure slurry bed levels. They also have problems with plugging pressure taps. Table II gives the measurement conditions.

#### 4.2.4 Temperature Measurement

Difficulties in measurement of temperature for process control occur with temperatures in the 1500°F (800°C) and above region, especially when temperature fluctuations must be followed and acted upon rapidly. A second high-priority temperature-monitoring need is for a means to detect hot spots on vessel walls in time to prevent damage to the vessel.

##### 4.2.4.1 Temperatures in Reactors and Combustors

Many conversion and combustion small-scale systems have problems with temperature measurement in their reactors or combustors. Although thermocouples are available which can measure temperatures in the range of interest (up to about 3000°F or 1700°C), there are serious problems in designing thermowells which can withstand the severe erosive and corrosive conditions and the high pressures. The higher temperature systems tend to be those for which temperature fluctuations must be detected and responded to rapidly, and a heavy thermowell introduces a delay in response.

Systems which have stated a need for temperature measurement are HYGAS (stage 2 gasifier at 1800°F or 1000°C), BI-GAS (stage 1 gasifier at 3000°F or 1700°C), Exxon (combustor at 1700°F or 950°C and future regenerator at 2000°F or 1100°C), and Pope, Evans and Robbins (Combustor at 1550°F or 850°C and carbon burnup cell at 2000°F or 1100°C). These conditions are summarized in Table II. Combustion power has fabricated their own type K thermocouples (rates up to 2500°F or 1400°C) which have been operating satisfactorily for over 600 hours at 1600 to 1700°F (900 to 950°C). They are sheathed in stainless and encased in Schedule 40 vertical steel pipes extending to various heights in the bed.

##### 4.2.4.2 Temperature of Vessel Walls (Hot Spots)

There is a need in all the conversion and combustion processes for an improved method of detection of hot spots on vessel walls and pipes. This condition would indicate wearing away or cracking of the insulating ceramic liner and would be followed by damage to the vessel or pipe material unless the process could be shut down in time to prevent it. Most plants use a temperature-sensitive paint to indicate hot spots by a change in color, but these paints have a slow response and are strongly dependent on ambient conditions.

#### 4.2.5 Other Instrumentation Needs

A few other instrumentation needs have been called to the attention of ANL during this study which may be serious for only one or two processes. SRC would like a device which could locate a plug (where the process liquid had dropped below its melting point) in a long pipe. They also need an improved method of pressure measurement, not so subject to plugging. This is essentially the same problem encountered in fluidized-bed height measurements by differential pressure techniques. Both Synthoil and SRC will need on-line viscosity measurement, but have not yet tested available instruments. It is expected that the available instruments will be satisfactory.

## 4.3 Other Deficiencies

Three areas of need came to the attention of ANL during this study which, while not within the scope of the study, bear on the ability to control large-scale coal conversion and fluidized combustion systems.

### 4.3.1 Automatic Control Schemes

Although work has been done in mathematical modeling and control-optimization studies of some of the coal conversion and fluidized combustion processes,[1] and one process (Combustion Power FBC) is fully automated, there has been in most cases a serious lack of attention to the development of control schemes for automatic control. Work on this problem is clearly necessary before demonstration plants can be operated, and would complement instrumentation development by quantifying instrument development incentives for process optimization. In turn, instrument development would provide input for the control scheme development by identifying options and through data on what parameters can be monitored and with what accuracy and precision.

### 4.3.2 Valves

The deficiencies in instrumentation for automatic process control in large-scale coal conversion and fluidized-bed combustion are paralleled by deficiencies in control valves to effect changes on operating conditions in response to signals from the instruments. Valves which can withstand the erosive and corrosive conditions and which can seat securely in the presence of ground coal, char, or ash against high pressure differentials are not available. There is a serious need for development of control valves of sufficient capacity, which can operate reliably and with reasonable lifetime in the environment of the process streams in these plants.

### 4.3.3 Technical Information Exchange

There appears to be a need for greater communication among personnel working on the various processes. Several cases have been found during this study where a problem at one plant had already been worked on and solved, at least partially, at another plant. Some areas where this has been apparent are temperature measurement with thermocouples, bed level measurement with differential pressure, and dirty gas analysis with chromatographs. It would surely accelerate the development of coal conversion and fluidized-bed combustion processes if the people involved were fully aware of work on common problems being done at other plants.

## 4.4 Search for Available Alternative Instruments

Both ANL and Fluor Pioneer conducted rather extensive (but not exhaustive) searches for other instruments now available or expected to become available within the next few years which might be able to perform some of the needed meaasurements, but which have not yet been tested in present small-scale coal plants. A small number of instruments were found which may be able to meet some of the deficiencies described in Table II. These instruments, which represent possible alternatives to the instruments currently used in pilot plants and process development units, are discussed below.

4.4.1 Alternative Instruments for Mass Flow

The flow rate of water-based slurries can be measured with an accuracy of about 1% using electromagnetic flowmeters available from Foxboro, Honeywell, and a number of other manufacturers. Texas Nuclear has a complete system which combines an electromagnetic flowmeter and a nuclear density gauge to give computed mass flow rate. Several processes employ water-based slurries for carrying away ash or mineral residue, but the temperatures are above the roughtly 350°F (200°C) limit of electromagnetic flowmeters. The only measurement need found in the study which can be met with the electromagnetic flowmeter occurs in the HYGAS plant when the coal (lignite) is slurried with water for injection to the gasifier. The HYGAS process usually slurries the coal with oil, in which case the electromagnetic flowmeter will not work.

Thermal Instrument Company markets a line of thermal flowmeters (which give mass flow directly) which they claim can measure slurry flow, non-airborne solids flow, and dirty gas flow (particle entrainment not measured). The advertised accuracy is 1%, range is 10:1, temperature limit is 1500°F (800°C), and pressure limit is 60,000 psi. These devices have been used in coal/oil slurries but have not been tested in coal conversion or FBC systems. One of these devices has been installed in the char return from the cyclone separator in the BI-GAS plant and will be tested when the plant begins operation in 1976. Solids mass flow in pneumatic transport or in dirty gas flow cannot be measured by this technique.

4.4.2 Alternative Instruments for Composition

No instruments were found which could monitor composition of solids on-line. In the area of elemental and molecular composition of gases, two instruments appear to have potential for solving some of the problems experienced with instruments now being used in the coal plants for gas analysis. A mass spectrographic system available from Extranuclear Laboratories still requires sampling, but, according to the manufacturer, is able to monitor up to 16 at a time of all elements and compounds of interest with a response time of 10 msec per gas, accuracy 1.5% of reading, and range of 1 ppm to 100%.

An atomic absorption technique has been under development for several years at Lawrence Berkeley Laboratory which is able to detect many of the elements and diatomic molecules of interest.[2] It utilizes the Zeeman effect to give several source lines of slightly different wavelengths so that the wavelengths not absorbed by the sample may be used to determine background absorption, a major source of uncertainty in conventional atomic absorption measurements. High temperatures of gas streams in coal plants would not be a problem since the sample is routinely heated to 3000°F (1700°C) or higher. Because cross sections for atomic absorption are generally high, samples might have to be diluted to reduce absorption when measuring concentrations of non-trace elements. A version of this instrument is available from Nissei Sangyo Instruments. Scientists at LBL believe the device could be designed for use in a coal plant.

### 4.4.3 Alternative Instruments for Level

Gamma level gauges are available from a number of commercial sources: Kay-Ray, Industrial Nucleonics, Texas Nuclear, and others. They work well when there is a 15% or more difference in densities across the boundary and are not bothered by conditions within a vessel since they are not in contact with it. The biggest problem in applying this technique to vessels in large-scale coal plants arises because of the large amount of dense material in the walls compared with the much less dense material within the vessel. This masks the difference in density across the boundary. These devices might be able to measure liquid levels where a gas is above the liquid, but probably would not be able to detect fluidized bed levels. They cannot, as stated in Section 4.2.3.1, detect oil/water interfaces.

### 4.4.4 Alternative Instruments for Temperature

A device suitable for monitoring temperature increases of pipes and vessel walls is a continuous thermistor available from Walter Kidde. The thermistor strip can be as long as 400 feet (120 m) and gives a signal proportional to the mean effective temperature. Thus a small very hot spot would give the same signal as a larger area that was proportionately less hot. A device of this kind is being installed on the Synthane gasifier and will be tested with the Synthane plant begins operation.

Radiation pyrometers are available from many sources: Laser Precision, Wahl, Ircon, Pyrometer Instrument, and others. They can measure temperatures up to 7000°F (4000°C) and detect radiation from the ultraviolot to the far infrared. They might be able to measure temperatures in vessels if an optical path could be furnished, but it is unlikely that it could. They probably can be used to detect hot spots on pipes and vessel walls. A likely scheme would be the installation of the thermistor strips described above to warn of temperature increase to be followed by scanning with a radiation pyrometer to locate the hot spot and measure its temperature.

## 4.5 Survey of Promising New Techniques

In this section, a number of techniques which show promise for meeting instrumentation needs in coal plants are described.

### 4.5.1 New Techniques for Mixed Phase Mass Flow

Mass flow in a pipe is a measure of the amount of material passing through a given cross section of the pipe per unit time. If the weight per unit volume (density) of the flowing medium is designated by $\rho$(lbs/ft$^3$) and the average speed of travel along the pipe of particles in the medium is given by v (ft/sec), then the mass flow through a pipe of cross section of area A(ft$^2$) is given by $\rho vA$ (lbs/sec). Several of the techniques described below are based on measurement of quantities which depend on $\rho v^2$ or v rather than the product $\rho v$. In these cases, a second measurement -- usually of $\rho$ - can be combined electronically with the first to give a computed value of $\rho vA$, the mass flow.

### 4.5.1.1 Acoustic/Ultrasonic

#### Background

Acoustic/ultrasonic techniques pertinent to coal plant instrumentation do not measure mass flow directly but yield dimensionally-related quantities such as the velocity of the medium, v (ft/sec), the velocity of sound in the medium, c (ft/sec), the Mach number (v/c), and the acoustic impedance $\rho c (lb/ft^2 sec)$.[3,4] Given the pipe area A and these measurements (and/or independent non-acoustic measurements of density) it is possible to calculate mass flow $\rho v A$ (lb/sec). Acoustic mass flowmeters have been developed using the product of the Mach number and the characteristic impedance $(v/c)(\rho c) = \rho v$. Others have been developed using the direct product $\rho \cdot v$, where v was measured acoustically and $\rho$ was measured by non-acoustic methods, namely, dielectric constant and/or gamma ray transmission.

Before proceeding to the three process categories, some attention to basic recurring acoustic properties of material systems is in order. The materials, whether in gas, liquid, or solid phase, are characterized by density, various moduli, and size relative to the acoustic wavelength. The first two specify the propagation of sound in the material. The velocity of sound $c = \sqrt{k/\rho}$ where k is the appropriate modulus and $\rho$ is the density.

Across phase boundaries (for example, solid-liquid, solid-gas or liquid-gas) there is usually a sharp change in density with corresponding changes in velocity of sound and characteristic impedance. These material properties govern the refraction, reflection, and transmission of sound and must be accounted for in considering the feasibility of applying different methods of measurement to the three categories. Refraction follows Snell's law, $c_1/\sin\Theta_1 = c_2/\sin\Theta_2$, as in optics. Transmission and reflection at boundaries follow the usual impedance relations which at normal incidence give $T = 4 Z_1 Z_2/(Z_1 + Z_2)^2$ and $R = (Z_1 - Z_2)^2/(Z_1 + Z_2)^2$, respectively, where $Z_1 = \rho_1 c_1$ and $Z_2 = \rho_2 c_2$ are the acoustic impedances.[3]

These relationships hold in gases and liquids, in which only dilatational acoustic waves can propagate. In solids the concepts must be extended to account for other modes, principally shear waves. The latter are used to advantage in some commercial clamp-on type ultrasonic flowmeters. The advantages come in terms of improved refractive angle (i.e., the acoustic wave moves more nearly parallel to the fluid flow vector) and in reducing or eliminating interfering or "short circuit" paths through the pipe walls.

Implicit in the large difference of density between gases and solid/liquid phases is large reflection R (including scatter) and corresponding low transmission T. This is particularly important in selecting acoustic methods for application to mass-flow measurements where two phases exist.

Fluid flow speed can be determined by several active (i.e., having a transmitter) acoustic/ultrasonic methods: (1) Differences in time for propagation of sound over a fixed distance with and against fluid flow, (2) Doppler shift of frequency of sound waves reflected from a flowing medium, or (3) Deflection of an ultrasonic beam by a flowing fluid. In one variation of the time difference method, there are two sets of transducer-receiver pairs, pairs, one producing ultrasonic beam pulses at an angle with the flow and the other giving beam pulses at an angle against the flow. The received pulses are used in a feedback loop to trigger the transmitted pulses in a self-excited oscillator arrangement. Because of the additive and subtractive effect of the flowing fluid on the acoustic wave propogation, the natural period of the forward loop $t_1 = L/(c + v\cos\Theta)$ is less than that of the backward loop, $t_2 = L/(c - v\cos\Theta)$. (c is the speed of sound in the flowing medium.) A beat frequency $\Delta f = (1/t_1) - (1/t_2) = (2v\cos\Theta)/L$ is obtained by electronically mixing the two signals and is proportional to the flow speed as well as independent of the speed of sound in the flowing medium.

In a second variation of the time difference method, the flow produces a phase difference rather than a frequency difference between acoustic waves arriving at one of two receivers placed across the pipe and equidistant upstream and downstream from the transmitter. It should be pointed out that the frequency differences in the former method or the phase shifts in the latter are quite small for low flow speeds, on the order of a few feet per second, but they are measurable using state of the art technology. Although in principle the acoustic transducers and receivers may be placed outside the pipe in the above two methods, in practice it may be necessary to introduce wave guides inside the pipe in order to achieve sufficient coupling of the acoustic signal with the flowing medium and to reduce interference due to pipe-fluid interface effects.

An existing commercial device known as the "clampitron"[5] utilizes a direct time-of-flight measurement and can be strapped to the outside of the pipe. However, it appears to be limited to fluid mediums which are not too highly attenuating, and this could well eliminate its practical application to slurry flow. Nevertheless the active acoustic devices have sufficient potential to warrant developmental effort.

Passive (i.e., listening to noise generated by the system) acoustic/ultrasonic flow measurement is also possible. During turbulent flow or during the transfer of solid particles, sound is generated in the transfer lines due to interaction between the flowing material and the pipe wall. Highly sensitive commercially available acoustic emission receivers can detect these sound waves even at very low signal amplitudes. Frequency discrimination can be employed to cut out "background noise" from sources other than the flow stream or to separate noise due to turbulent flow from that due to flow of solids in a slurry. This method is potentially useful in all the categories of flow measurement under consideration. In contrast to the "absolute" transit time flowmeters just discussed, an acoustic noise device must be independently calibrated.

Acoustic noise techniques may also be applied to the detection of leaks. Leaks as small as 0.1 cc/sec may be detectable by acoustic emission sensors.[6] This technique may be applicable to monitoring leaks of critical valves in the coal conversion plants.

An acoustic receiver may be used simply to detect a change from normal operating conditions. Crude noise level devices of this kind are in use at the Synthane gasification plant at Bruceton, Pennsylvania and at the Exxon fluidized-bed combustion miniplant at Linden, New Jersey.

Devices which are based on the concept of acoustic noise proportional to turbulent flow are now commercially available for moderate temperatures up to 300°F.[7] Acoustic emission signals over a large frequency range (0-200 kHz) as a function of flow of liquid sodium coolant at EBR-II have been measured at ANL by Anderson et al.,[8] and their work shows a strong correlation of relative sound level with flow rate.

If the flow includes solid particles, the relevant frequency range is much higher than for conditions of turbulent flow alone. Mullins et al.,[9] have developed an acoustic detector which is capable of monitoring the flow of sand in a pipe. They find that a narrow band around 700 kHz is the best frequency "window" for monitoring sand flow. The sound level is proportional to the kinetic energy of the sand.

These methods of ultrasonic flowmeter are shown in Table III along with the measured parameter and the measurand.

TABLE III. Ultrasonic Flowmetering Methods

| No. | Method | Measured Parameter | Measureand |
|---|---|---|---|
| 1 | Transmission | Times of Flight | v, v/c or $v/c^2$ |
| 2 | Reflection (Doppler Scatter) | Frequency Shift | v/c |
| 3 | Beam Drift | Drift Distance or Angle | v/c |
| 4 | Noise | Acoustic Pressure | $v^n$, n > 1 |

These methods have been well described in survey articles by Lynnworth[3] and by Liptak and Kaminski.[4] Reference 4 includes a survey of product lines of 17 manufacturers of ultrasonic level and flow instruments.

Applications at high temperature (T > 300°C) have not found large markets to date. Transducer and coupling materials have also limited high temperature applications. Development of high temperature transducers at the Argonne National Laboratory has been described by Gavin et al.,[10] and Karplus.[11] Using lithium niobate piezoelectric crystals, 304 stainless steel housings, and high temperature cables, they have achieved extended operation in the range 700° to 1200°F (400° to 700°C). Operation at still higher temperatures is possible, the limits being set by the housing metal and the bulk resistivity of the lithium niobate. Tests at temperatures above 1200°F (700°C) for operation and survival of the transducers are needed. It is necessary to provide an oxygen atmosphere to the lithium niobate crystal to prevent chemical reduction of the surfaces with a resultant electrical low resistance or short circuit. External static pressure does not affect the ultrasonic performance.

In response to the questions of applicability of their commercial ultrasonic flowmeters to slurries, vendors indicated limited applicability for transmission types based on measuring time, phase, or frequency difference.[4] One manufacturer (Badger Meter) specified applicability up to 8% solids. The limitations are based on loss of transmitted signal due to scattering and absorption by the solids suspended in the slurry. Since these systems were designed for pure fluids, the transducer frequencies may be higher than necessary. Thus one of the areas to be explored for slurries is to study the scattering and absorption of acoustic waves in slurries as a function of frequency. Similar limitations or not applicable were noted for "Liquids with Gas Bubbles".

The only type of ultrasonic flowmeter offered by commercial sources for slurries, liquids with gas bubbles, and fluidized conveyed solids was the noise type based on particle impingement.[4]

## Feasibility for Dense Phase Solid/Gas Flow

The conditions listed in Table II are such as to make conventional transmission type ultrasonic flowmeters unfeasible except at very low frequencies. This results from the problem of coupling acoustic waves to the gas, which is very inefficient, along with the scattering and absorption. However, the scatter problem suggests a possible solution by measuring the velocity by Doppler frequency shift of a reflected acoustic wave. Further complications to this approach result from variations of the velocities of the solid particles between themselves and the carrier gas.

Tests of penetration of acoustic waves as a function of the solids density, stream pressure, and frequency of the acoustic wave will be required to assess the feasibility. If penetration is insufficient, the portion of the flow profile sampled may not be representative of the total flow.

Development of acoustic transducers for specific applications at high temperature and/or high pressure would be required, based on existing ANL technology.[10,11]

The combination most likely to succeed is a passive noise type ultrasonic flowmeter coupled with a dielectric constant or gamma ray transmission type density meter.

## Feasibility for Solid/Liquid Slurries

Preliminary tests in the 1-5 megaHertz frequency range show that addition of 200 mesh coal to water or oil causes severe attenuation. However, low frequency clamp-on transducers appear to make transmission type ultrasonic flowmeters possible for velocity measurement in this requirement. In order to assess the feasibility and obtain transducer design parameters, experiments are needed to measure acoustic velocity, attenuation, and impedance of slurries as a function of frequency, temperature, and composition of representative slurries. Also, tests are needed of transducer operation and survival at temperatures above 1200°F (700°C).

Passive ultrasonic flowmeters and non-acoustic density meters represent a fallback approach to slurry mass flow measurement.

## Feasibility for Dilute Phase Solid/Gas Flow

Velocity measurement using a low-frequency transmission type ultrasonic flowmeter measuring phase difference may be feasible for cases in which attenuation due to particulates and/or long path is not excessive. Tests of transducer operation and survival are needed in the temperature range 1200-1500°F (700-800°C). Because of impedance mismatch between transducer and the gas, it is difficult to transmit and receive acoustic waves via gas and special attention to transducer design is needed.

Passive, noise-sensing-type ultrasonic flowmeters are feasible.

Doppler-type frequency-shifted reflection ultrasonic flowmeters do not appear feasible. Since the velocity measure is based on reflection from particles for which there will be a velocity distribution with particle size and type (different materials), an ambiguous result is likely. Also, the combination of low velocities with low frequencies make the Doppler shift small. Hence, this method is considered to have a lower likelihood of working for this requirement than the transmission or passive types.

Ultrasonic measurement of density via acoustic impedance is not considered feasible.

Feasibility for Gas-Entrained Particles Flow

Application of active ultrasonic flow and impedance measurement to this requirement does not appear feasible with existing technology, principally because the large density ratio and corresponding impedance mismatch leads to inefficient coupling of acoustic/ultrasonic waves into the gas.

A passive acoustic technique is promising as a very simple means of getting information on number of particles (by frequency of impact) and size distribution (by violence of impact).

4.5.1.2 Capacitive Density

Unless a flowmeter measures mass flow directly (which is the case for only thermal and angular momentum flowmeters), a separate measurement, most commonly of density, is needed in order to compute the mass flow.

Background

Conceptually, the insertion of any material between the plates of a gas-filled capacitor will increase the measured capacitance. For a dilute concentration of homogeneous particles, whether metallic, semiconductor, or dielectric (insulator) material suspended in a low dielectric medium (gas or plastic foam), the change in capacitance will be proportional to the concentration of particles in the field of the capacitor; hence, proportional to the mass or density. Such a system might be successful for solids density measurements in a coal or char in gas line or coal/water slurry line where the effect of the solid particles on capacitance is very different from the effect of the vehicle medium. A device based on this principle is under development at Oak Ridge National Laboratory for determining relative amounts of two liquids having different dielectric constants.[12]

Feasibility

Capacitive density measurements of solids density or solid/fluid ratio in coal plants are consideded feasible for solid/gas systems because the dielectric constant of the solid is two or more times that of the gas. In a solid/water system, the dielectric constant of the water is at least ten times that of the solid. These statements are based on physical constants measured at 100°C or less and may have to be revised at much higher temperatures.

In a solid/oil slurry, the feasibility is questionable because of similar dielectric constants for the two materials. It may be that at some frequencies the dielectric constants will differ sufficiently to measure solid/oil ratios by this method.

4.5.1.3 Nuclear Flowmeter

Background

There are two basic methods by which radioactivity in the flowing medium may be used to measure flow velocity. Both involve the use of two radiation detectors at a known distance from one another along the stream. In the first method, the radioactivity is confined to a small region in the flowing medium, then a measurement of the time required to pass from the first detector to the second (a known distance from the first) suffices to give the flow speed. In the second method, the radioactivity is dispersed through the flowing medium, and the difference in activity detected at the second detector depends directly on the known decay constant and the time required for the medium to travel between the two detectors. With the time calculated, the speed can be found using the known distance.

Feasibility

The radioactivity may be introduced by putting pellets containing a long lived activity into the stream and recovering them downstream. This appears to be impractical in coal processing systems. An alternate method consists of the injection of a short-lived activity (a few seconds half-life) at a constant rate. If a small enough amount of radioactivity with a short enough half-life could be used, the amount of radioactivity exiting the process could be kept negligible, according to a study by a Polish group.[13] An interesting feature of this study is that distinct peaks related to the different flowspeeds of the coarse and fine grained fractions and of the water are observed.

Radioactivity may be induced in elements already present in the stream by bombarding through the pipe wall with a neutron source. A possible candidate for this technique is aluminum, which becomes radioactive upon absorption of a neutron and decays with a 2.3 minute half life, emitting a 1.78 MeV gamma ray. There are a number of other possibilities among elements naturally present in coal. It would also be possible to add traces of a substance which would not affect the process but which would be readily activated by neutron bombardment.

Neutron activation was used by Boswell and Pierce[14] to measure the flow speed of liquids, solids, and slurries by counting the induced radioactivity formed in the moving material as a result of irradiation. Both basic methods were used, one measuring the ratio of activity of the stream at two positions downstream of the place of irradiation and the other measuring the time taken for activity formed by a neutron pulse to travel between source and detector.

An attractive feature of the neutron activation approach to flow measurement is that it might be combined with composition monitoring by analysis of the gamma rays emitted upon neutron irradiation of the coal or char.

#### 4.5.1.4 Nuclear Density

Background

A nuclear density gauge consists of a radioactive source placed on one side of the sample whose density is to be measured and a radiation detector placed on the opposite side. The radioactivity which interacts with the material in the sample doesn't reach the detector. Thus the decreased radioactivity detected when a sample is present is an indication of the amount of material in the sample.

Feasibility

Density gauges based on attenuation of radiation from a gamma ray source are fairly common and appear to work well.[15] Since the gammas interact primarily with the electrons in material, the quantity measured is really the electron density. To the extent that the electron density is proportional to the nuclear density (or equivalently, the number of protons, Z, is proportional to the number of neutrons plus protons, A, in nuclei), the macroscopic density may be inferred from the gamma ray attenuation. For most elements, particularly the lighter ones, Z is approximately one-half A. However, in the case of hydrogen, Z equals A. Thus a variation in the relative amount of hydrogen present changes the calibration of the gamma density gauge. This may be serious in density measurements of some process streams in coal conversion and combustion plants since hydrogen is an important constituent of coal and a major component of the vehicle medium.

On the other hand, neutrons interact with the nuclei themselves, and the attenuation of a beam of neutrons passing through a sample is comparable in magnitude to the attenuation of gammas of similar energies. It may be possible to devise a density gauge based on attenuation of neutrons from a neutron source.

A third possibility is the combination of gamma and neutron attenuation measurements to give an acceptably unambiguous density determination.

These methods of density measurement are expected to work both for dense phase solids flow and dilute phase solids flow streams.

4.5.1.5 Noise Correlation Flowmeter

Background

Normally a system variable such as density, speed, pressure, or temperature will have local fluctuations superimposed on the average values. If such a variable is measured at one point along a pipe containing a flowing medium, and if the fluctuations persist long enough in a region of the flowing medium, the same fluctuations can be detected in a downstream measurement at a later time corresponding to the transit time of the medium between the two measurement points. Comparison of the two signals as a function of time delay of the first will show maximum correlation when the time delay equals the transit time of the medium between the two measurement points.

Feasibility

Computerized transit time cross-correlation techniques have been in development for more than a decade, particularly for application to measurement of coolant flow in the liquid sodium cooled fast reactor. The measurement of temperature fluctuations in the flow stream for determining flow rates has been investigated by Randall,[16] Ashton and Bentley,[17] and by Boonstoppel, Veltman, and Vergouwen.[18] The requirements of long measurement time and complicated computing equipment have been serious disadvantages of this method, although the last-mentioned group appears to have reduced these problems. The first two groups viewed the method primarily as an accurate means of checking the calibration of existing flowmeters in their natural environments.

An ultrasonic cross-correlation flowmeter is being developed at Canadian General Electric.[19] It will have the same limitations with respect to attenuation and temperature as the acoustic/ultrasonic flowmeters (4.5.1.1). Accuracies are expected to be 1 to 2% of reading.

This method would be practical in an advanced coal conversion or combustion system only if recent developments in electronics could be used to bring the necessary sampling interval down to a few seconds to yield a flow measurement with an accuracy of a few percent. Preliminary studies at ANL using two gamma density gauges have indicated that such performance is possible under conditions encountered in cyclone dip legs.

4.5.1.6 Charge Tagging Flowmeter

Background

Tagging methods include some of the oldest and simplest methods for measurement of flow. A portion of the flowing medium or a particle suspended in it is recognized at an upstream point, often by virtue of an artificially impressed tag, and its progress downstream is monitored. The flowrate may be determined from a measurement of the transit time as in the particle or pulse tracking technique or from a measurement of concentration or radioactivity level as in dye/chemical dilution or radioactive tracer techniques. When they are feasible, these methods are efficient, rapid, and usually do not require calibration. In addition tagging can often be accomplished without entering the pipe, and many tagging methods can be applied to one-component or to multicomponent flow.

Feasibility

An electromagnetic tagging method of flow measurement in which charge is sprayed onto gas-entrained particles using techniques similar to those used in a van de Graaff generator shows promise for measurement of dilute phase flows. These charged particles then pass downstream to make their presence known at one or more pickup electrodes by induction or charge collection. The time of passage between two points a fixed distance apart gives the speed of the entrained particles. Alternating polarities may improve signal to noise ratio and prevent net charge buildup. The amount of local charge buildup may convey information about the size and nature of the particles, and the degree of formation of electronegative gas ions may give information on oxygen concentrations.

### 4.5.1.7 Eddy Current Flowmeter

Background

The eddy current flowmeter[20] is, like the electromagnetic flowmeter, based on Faraday's law of induction. An alternating magnetic field created by a primary coil induces eddy currents in conducting paths in the flowing medium. A secondary coil whose two sections of series-opposed windings are located on the upstream and downstream sides of the primary coil is adjusted to give zero output voltage when there is no flow. When flow occurs, eddy currents in particles flowing into the region of one section of the secondary coil cause a net output voltage to appear across the secondary coil. The eddy current flowmeter was developed at ANL for measuring flow of liquid sodium at temperatures too high for electromagnetic flowmeters. It is marketed by Kaman Nuclear.

Feasibility

This technique in theory would work when conductive particles are flowing in a non-conductive medium, as in the case of hot char flow in dense or dilute phase. Whether the char is sufficiently conducting will have to be determined.

This technique is feasible for measurement of flow in the HYGAS steam-iron hydrogen producer where flow streams contain large amounts of iron metal.

### 4.5.1.8 Optical Flowmeter

Background

Fluid-borne particles can be recorded in situ (in a light transmitting medium) by detectors, such as photographic film, yielding shadowgraphs[21] or holograms, depending upon the optical configuration. The usual mode of particle detection using a holographic system has of necessity employed pulsed lasers. The resulting static holographic image can be displayed continuously by using a visible spectrum continuous wave (cw) laser in the image reconstruction process.

The disadvantage to this system is that it is not real time and requires a dark-room region when making the initial exposure to avoid fogging the film. The advantage is that the hologram records the entire depth of field allowing the reconstructed image to be scanned for both in-plane size and depth of field distribution (assuming the coherence length of the laser is sufficient to cover the depth of field; typical coherence lengths are in excess of 1 meter). What is needed is a real time system which would possess all the desirable features of the static hologram.

The recently-developed system[22] has been described which is an initial attempt to meet this need. Shadows cast by the light from a rapidly firing (60 pulses per second) ultraviolet laser are received on a UV sensitive vidicon camera. The camera output is coupled to both a videotape deck and a television receiver. The videotape recording allows the dynamic action to be viewed at a later time at a slower rate or in stop action. The system developed employs a variable focusing mechanism which allows the plane of view through the flow field depth to be varied. The fundamental lack of this system is that the depth of field cannot be made available at an instant in time and thus a time dependent action in a cyclone could possibly be missed. A rapidly moving film transport coupled to a pulsed-laser holography system would allow dynamic flow fields, with complete depth of field, to be observed. A system which would automatically process the film, in fixed segments, would yield an almost real time system (approximately 15 minutes delay) with full depth of field. Rapidly moving holographic film transport mechanisms have been demonstrated for holographic movies. The development of such a system would significantly improve the analysis of cyclone efficiencies and materials balance studies.

The principle of measuring the Doppler shift of scattered electromagnetic radiation produced by inhomogeneities in a moving fluid has been applied in recent years to the measurement of flow. An experimental flowmeter based on the Doppler shift of microwave radiation has been used to measure the motion of a suspension of polystyrene beads in water.[23] Such a device would not have sufficient spatial resolution to be useful in monitoring particle motion in the aerosol from a cyclone and would be less applicable than, say, an ultrasonic Doppler device in measuring slurry flow. However, the advent of coherent light sources has made possible the application of this kind of device in the optical regime.

In the laser Doppler velocimeter,[24] a laser beam is focused into the spot at which the flow is to be investigated. Most of the incident beam energy propagates undisturbed with unchanged frequency through the flowing medium while a small part of the incident light is scattered in bursts as the small particles move through the focus. The resulting Doppler signal represents a random superposition of such light bursts which are interferometrically superimposed with the unshifted reference signal. This device can be used to give a point-by-point velocity profile, but as with the laser-imaging system just discussed, the depth of field cannot be made available at an instant in time. The laser Doppler method can be made a real time system more easily than can the laser-imaging method, but it cannot be used to determine particle size.

Recent work by engineers at Environmental Systems Corporation[25] has shown that scattered light from a pulsed-laser source can be related in a fairly simple way to particle size distribution and solids mass loading in a gas stream. They currently market a line of instruments, which operate at temperatures up to 650°F, based on this principle for monitoring of atmospheric dispersion of drift particles from cooling towers and of stack gas particulates.

Feasibility

Several industrial laboratories have developed laser scattering, interferometry, and holography techniques for measurement of particle size distribution and total particle mass loading of gases. Upgrading these systems to operate at the pressures and, especially, the temperatures required for measuring particle entrainment in product and flue gases in the coal plants will be difficult. However, Environmental Systems Corp. and Leeds and Northrup believe they can extend their scattering instruments into the necessary temperature range. Spectron Development Laboratories is prepared to develop their interferometric system for operation in coal plants.

### 4.5.2 New Techniques for On-Line Composition Monitoring

#### 4.5.2.1 Neutron Capture Gamma Analysis

Background

When an atomic nucleus of a given element captures a neutron, it becomes a nucleus of a different isotope of that element with an excess of energy. This excess energy is usually carried away by one or more gamma rays -- usually in the neighborhood of 3 to 8 MeV (1 MeV = $1.602 \times 10^{-13}$ Joules). Each element has a unique set of gamma ray energies emitted upon capture of a neutron. Therefore a knowledge of the appropriate characteristic gamma rays and the probabilities of neutron capture by several elements permits the gamma ray spectrum to be analyzed for the relative amounts of the different elements in a neutron-irradiated sample. Since energetic gamma rays and neutrons travel large distances in matter, it is possible to beam neutrons into the material in a pipe and detect the gamma rays coming from it without modifying the pipe in any way.

The difference between neutron capture gamma rays and gamma rays from neutron activation analysis is worth pointing out. The initial stage is the same in both processes: a nucleus captures an additional neutron and forms a new isotope with an excess of energy. However, neutron capture gamma rays result from the transition of the nucleus to a lower state of that same nucleus (a process which typically occurs within $10^{-15}$ sec) while in neutron activation analysis the excited nucleus decays by particle emission to an excited state of another nucleus (a process characterized by half-lives of seconds, minutes, or even longer) which then emits gamma rays in the transition to lower states. In this latter case, the delay seen in emission of the gamma rays is a result of delay in the formation of the nucleus which emits the gamma rays.

The number of gamma rays of a given energy emitted from a sample will be proportional to the number of neutrons absorbed by the appropriate element, the number of gamma rays of that energy emitted when a neutron is absorbed, and the number density of the nuclei of that element in the sample. The number of neutrons absorbed in an element is proportional to the neutron absorption cross section $\sigma$. The number of gamma rays emitted is given in published tables of I,[26-28] the number of gamma rays of a given energy emitted per 100 neutrons absorbed in an element. The mass density of an element divided by the mass of an atom, or the atomic mass A, gives the number density. Since the mass density will be proportional to the percent by weight, W, of the element in the sample, a response index which gives relative expected gamma ray emission from a sample can be formulated as $\sigma I\ W/A$.

## Feasibility for Measurement of C,H,O,S, and Ash Content of Streams and Vessels

A recent report by the Illinois State Geological Survey[29] lists analyses for 101 different coals -- 82 from Illinois, 11 from the eastern U.S., and 8 from the western U.S. Mean analytical values are given for 23 trace elements (antimony, arsenic, beryllium, boron, bromine, cadmium, chromium, cobalt, copper, fluorine, gallium, germanium, lead, manganese, molybdenum, nickel, mercury, phosphorus, selenium, tin, vanadium, zinc, and zirconium) and for 14 minor and major elements (aluminum, calcium, chlorine, iron, magnesium, potassium, silicon, sodium, sulfur, titanium, carbon, hydrogen, nitrogen, and oxygen). Using these mean values for the weight percentages, response indexes were calculated for the principal gamma ray lines of all these elements. Table IV lists the elements, gamma ray energies, and response indexes, assuming thermal neutron absorption, for all cases where the gamma energy is greater than 1 MeV and the response index corresponding to the mean concentration of that element is greater than 15% of the response index of the principal line of carbon at its mean concentration. In cases where more than four lines satisfy these criteria, only the four strongest lines are listed.

The only trace element which satisfies these requirements is boron, so interference from trace element contamination should not be a problem. All the ash-forming elements except sodium, magnesium, and potassium respond satisfactorily. Hydrogen has the greatest response index of any element in coal, and a satisfactory response is indicated for carbon. Nitrogen has too small a concentration to give a good response, and oxygen essentially does not respond to this technique.

Small, portable neutron sources are available as Californium 252, a spontaneous-fission source with a 2.65 year half-life and a mean neutron energy of $\sim$2 MeV.[30] Neutrons beamed into a coal-filled pipe would be slowed down in the sample itself to the thermal region where the absorption probabilities are generally very high.

Neutron capture gamma analysis has been tried for composition monitoring of various process streams both using a $^{252}$Cf source and a 14 MeV neutron generator.[31,33] Sulfur, silicon, iron, hydrogen, and carbon have been observed. However, there are many interferences among elements of

TABLE IV. Predicted Response of Elements in Coal at Mean Concentration to Neutron Capture Gamma Technique

| Element | Gamma Energy (MeV) | Response Index (Arbitrary Units) |
|---|---|---|
| Hydrogen | 2.223 | 163 |
| Boron | 1.889 | 0.980 |
| Carbon | 1.261 | 0.581 |
| | 3.684 | 0.633 |
| | 4.945 | 1.33 |
| Aluminum | 7.724 | 0.226 |
| Silicon | 2.093 | 0.380 |
| | 3.539 | 1.129 |
| | 4.934 | 1.001 |
| *Sulfur | 2.380 | 1.672 |
| | 2.931 | 0.840 |
| | 3.221 | 1.018 |
| | 5.420 | 2.220 |
| *Chlorine | 1.951 | 2.759 |
| | 6.111 | 2.038 |
| | 6.620 | 1.291 |
| | 7.414 | 1.100 |
| Calcium | 1.943 | 0.434 |
| | 6.420 | 0.232 |
| Titanium | 1.381 | 0.583 |
| | 6.418 | 0.325 |
| | 6.760 | 0.481 |
| *Iron | 5.921 | 0.747 |
| | 6.018 | 0.728 |
| | 7.632 | 2.449 |
| | 7.646 | 1.994 |

*Other gamma energy lines satisfy the response index criteria, but only the strongest four lines are given.

interest which are not easily resolved when using a sodium iodide gamma detector (as the above experiments did) because of its poor resolution.

Preliminary studies at ANL[34] using a high resolution lithium-drifted germanium detector indicate that the various peaks can be resolved and unambiguous determination made of hydrogen, carbon, sulfur, silicon, iron, aluminum, and calcium.

Neutron activation analysis has proved to be extremely valuable for the detection of trace elements,[35] but it involves the irradiation (or activation) of a sample for a period of time followed by a period of counting of the gamma rays from the decay-product nuclei. This counting is usually done in a different location from the irradiation to reduce background in the detector. Because the original energy has been partly carried away by the emitted particles, the gamma energies tend to be less than 1 MeV. All of these factors tend to make neutron activation analysis unsuitable for an on-line continuous composition-monitoring system for material within a heavy pipe. An exception is aluminum which is likely to become activated to a measurable extent during irradiation for neutron capture gamma analysis with a 2.3 minute half-life and emission of a 1.779 MeV gamma. This may be used to advantage for aluminum detection as well as for flow measurement by relating activity measured down-stream to upstream activity, through the known half-life, to give the time of transit.

#### 4.5.2.2 Fast Neutron Reaction Gamma Analysis

##### Background

Two other processes in which incident neutrons interact with nuclei produce gamma rays which can yield information about material in the sample. The first process is inelastic scattering in which the neutron bounces off the nucleus but leaves it in an excited state. The nucleus promptly (in most cases) decays to the ground state with emission of gamma rays. For this process to occur, the incident neutron must have sufficient energy to raise the nucleus to its first excited state.

The second process is a reaction in which the incident neutron merges with the nucleus and a different particle, usually a proton or alpha particle (helium nucleus), emerges leaving behind a different nucleus in an excited state. If this new nucleus decays to its ground state, prompt gammas will follow; if the nucleus decays to another nucleus by particle emission followed by gamma emission from the product nucleus, it is referred to as an activation process. In many reactions, there is a minimum (threshold) neutron energy required.

##### Feasibility for Measurement of C,H,O,S, and Ash Content of Streams and Vessels

Reasonably small, movable sources of 14 MeV neutrons are commercially available.[36] These operate by accelerating deuterons ($^2H$ nuclei) onto a tritium ($^3H$) target. The reaction $^2H + {}^3H \rightarrow {}^4He + n + 17.6$ MeV occurs. The neutron carries away 14 MeV of the 17.6 MeV released.

Inelastic scattering of neutrons from $^{12}C$ and $^{16}O$ may be useful for coal analysis. The 4.43 MeV gamma from the first excited state of $^{12}C$ could be triggered by neutrons of energies above 4.80 MeV; the 6.05 MeV gamma from the $^{16}O$ first excited state could be triggered by neutrons of energies above 6.43 MeV. The scattered neutrons from these and other nuclei in the sample would be subject to capture as they thermalized just as the neutrons from a $^{252}Cf$ source so that the neutron capture gamma analysis would be possible for the 14 MeV generator.

The reaction $n + {}^{16}O \rightarrow p + {}^{16}N$ with a threshold at a neutron energy of 10.24 MeV is a very useful and sensitive method for detection of oxygen.[37] The $^{16}N$ decays with a 7.4 sec half-life followed by the emission of 6.13 and 7.11 MeV gammas. This technique has been used for oxygen concentration analysis of process streams by automatic sampling,[38] and its feasibility for on-line continuous oxygen monitoring of moving streams has been demonstrated.[39] The possibility of using this activity in flow measurement (see Section 4.1.1) also exists.

The advantages of the 14 MeV generator over the $^{252}Cf$ source of neutrons are the possibility of oxygen detection and the fact that the generator can be turned off. Disadvantages are the more complicated gamma spectrum due to the larger number of gamma-producing interactions, the bulkier source, and the greater amount of shielding needed for the higher energy neutrons. Sealed-tube neutron generators are available which eliminate handling of the tritium targets by plant personnel.

### 4.5.3 New Techniques for Level Measurement

#### 4.5.3.1 Acoustic

**Background**

See Section 4.5.1.1 for a discussion of acoustic transmission and reflection at boundaries.

**Feasibility for Liquid/Liquid Interface**

The determination of liquid/gas interface level is considered highly feasible, subject to field determination of actual attenuation due to entrained particulates, emulsified globules or gas bubbles.

The determination of liquid/liquid interface levels is considered more difficult than liquid/gas, but feasible subject to the same restrictions. Preliminary tests at ANL of acoustic reflection from clean oil/water interfaces gave easily detectable reflections from the interface.

Non-penetrating high temperature ultrasonic transducers based on current Argonne National Laboratory technology[10,11] can be designed to be mounted outside the pressure vessel in which the liquid is contained. The electronics in commercial level gauges with reasonable modifications should be suitable for the level determination.

It will be necessary to measure the acoutic/ultrasonic properties of representative clean and "dirty" liquids and emulsions including: acoustic velocity, attenuation, and impedance as functions of frequency, temperature, and pressure.

Feasibility for Fluidized Bed Heights

Fluidized bed reactors represent a relatively new technology. Hence, there are few instrumentation examples related to fluidized bed reactor operation. The principal measurements to date are temperature (using sheathed thermocouples in protective wells) and differential pressure. The bed height fluctuates with the pressure and flow to the fluidizing gases. The height-defining interface is not sharp, the density varying continuously across the interface. Acoustic/ultrasonic methods must be considered as exploratory attempts to establish feasibility.

Determination of the fluidized bed height by echo detection on the gas side (i.e., from the top) appears sufficiently likely to warrant an exploratory test. This would be a non-penetrating or non-contact method. Other methods which would involve inserting solid rods into or through the bed are not recommended pending further study.

Temperatures above 1200°F (700°C) at the transducer location will require study and possible transducer development.

4.5.3.2 Electrical Time Domain Reflectometry (TDR)

Background

Time Domain Reflectometry (TDR) is the process whereby an energy pulse is transmitted and the time delay measured until the receipt of a return echo. The energy pulse can be of an electromagnetic or acoustic origin with an unspecified frequency. Common practice is to differentiate TDR from RADAR in the electromagnetic spectrum by restricting the transmission medium to solids or liquids and to differentiate TDR from SONAR by restricting the application to a more confined medium; there are, however, still areas of overlap.

The time delay associated with the return of an echo pulse is based on the velocity of transmission in the media and hence is dependent on the properties of the media through which it is traveling. A requirement on the echo pulse is that it must have sufficient magnitude and shape characteristics to be distinguished from other extraneous sources of energy and to provide adequate accuracy. The selection of the origin of the TDR energy (electromagnetic or acoustic) depends on what properties of the media can be used and what is desired from the measurement.

In electrical TDR for level measurement, a conducting wire extends vertically from top to bottom of the vessel. The wire and the vessel wall act as the two sides of a transmission line. An electrical pulse traveling down the line will reflect at a discontinuity in the electrical characteristics of the medium surrounding the wire.

Feasibility

Work at the Pittsburgh Energy Research Center has demonstrated feasibility of this technique for fluidized bed height measurement on small systems.[39] Further work is needed to determine if the accuracy obtainable in large scale fluidized beds is satisfactory.

The electrical TDR technique is feasible for determination of liquid/gas levels and is likely to work for oil/water levels.

4.5.3.3 Conductivity

Background

Pairs of electrical probes on opposite sides of the vessel and at various heights could be checked for conductivity through the medium in the vessel.

Feasibility

Since the conductivity of water is much greater than that of oil, this method would be useful for determining whether a pair of probes was in water or oil. Small height differences between pairs of probes would permit height determination, or the probes could be used in a switching mode to maintain the interface between desired limits.

4.5.4 New Techniques for Temperature

4.5.4.1 Acoustic TDR

Background

See Section 4.5.3.2 for a general discussion of TDR.

Properties of liquids and solids, although not as well behaved as those of gases, can be measured by acoustic TDR. Bulk modulus properties of liquids and solid are related to the velocity of sound, c, by the following equation: $c = \sqrt{k/\rho}$, k = relevant modulus, $\rho$ = density. Thus, if a wire containing sharp acoustic impedance changes is pulsed with properly selected acoustic energy at two temperatures, one of which is known, and the wire material properties are known, then the other temperature can be calculated. In the case of a longitudinal (extensional) wave in a wire the usual important property that is related directly to the temperature is the Young's modulus. For torsion waves the shear modulus would be the parameter of the importance. It should be pointed out there that it is not just the simple temperature coefficient of expansion making the wire longer, that gives a change in the measured time delay between the impedance-change points, but it is a combination of changes, principally the elastic modulus changes in the material, that result in the change in the speed of sound. Temperatures have been measured in rhenium wire up to its melting point 5757°F (3180°C).[40]

Another point that should be made is that the TDR technique is not restricted to conductors or even metals but also works with ceramics. Thus, adding ceramic technology to that of metal technology has made possible an increase in the selection of possible materials to be used as sensors.

One restriction on the use of acoustic TDR for temperature measurement is that the temperature measured is an average over the acoustic path and restrictions exist on the ability of a designer to reduce the path length beyond a given point.

A principal advantage of the method is that one or more average temperatures can be measured by use of a single acoustic path. To accomplish multiple measurements the acoustic path must contain changes in acoustic impedance at the beginning and end of each desired temperature monitoring segment. The multiple delay times can then be separated and applied to each segment. It has been reported that 10 or more temperature monitoring segments can be used.[41]

For using solid acoustic conductors the selection of materials depends on many parameters among which are:

1. The environmental conditions in which the temperature measurement is desired. One of the more important environmental conditions is temperature. The range of materials that can be used at lower temperatures is fairly wide but becomes more restrictive as the temperature increases. Selections from available materials might include the following: aluminum (to 1000°F or 540°C), stainless steel (to 2000°F or 1100°C), sapphire (to 3000°F or 1650°C), iridium (to 4000°F or 2200°C). Other refractory metals useful from 4000°F (2200°C) to 6000°F (3300°C) include molybdenum, niobium, tantalum, tungsten, and rhenium. Other important environmental conditions to be considered include: Phase of the medium to be measured, pressure, chemical reactions including the presence of a reducing or oxidizing atmosphere, acidity, erosion, electrical potential, solubility, and vibration. It should be pointed out that protection of an otherwise good acoustic selection may be possible by using a sheath material such as is commonly done for thermocouples. A distinct advantage of the use of acoustic techniques over the use of thermocouples is that the electrical insulation considerations needed for thermocouples may be neglected.

2. Size and shape parameters that are important include the length of the temperature measurement path, the distance to the temperature measurement location, and allowable sensor size. The reason that size and shape are important parameters is that the acoustic energy pulse is transmitted through the material at a fixed frequency and the frequency selection is dependent on the length, width, shape, acoustic impedance, attenuation, etc., which are functions of size and shape. Some of the considerations involved in selecting the right size and shape (and frequency) include:

a. In general, high frequency signals tend to have greater losses and attenuate more rapidly than lower frequencies so for longer distance measurements lower frequencies are better.

b. High frequency signals provide a higher accuracy for a given length of temperature sensing path by providing sharper time pulses and the resulting increased measurement accuracy.

c. Mode conversion of the acoustic energy is related to size and shape. That is shear, longitudinal and Rayleigh waves can be irreversibly and inadvertently interchanged causing loss of signal or severe errors in measurement. The different wave forms have different attenuation factors and velocities through the same material.

In order to use TDR it is necessary to transmit and receive an acoustic signal in an acoustic transmission media; to accomplish this acoustic transducers are needed. Many types are available and the selection of a particular type depends on the environmental conditions at its intended location, the medium in which the transmission is to take place, the desired frequency of the acoustic pulse, strength of the signal to be transmitted and received, and cost. The types available include transducers that operate both as the transmitter and receiver and those that operate only as a transmitter or a receiver. The types are differentiated principally by their basic principle of operation and include piezoelectric, electrodynamic, electrostatic, and magnetostrictive devices which can usually be used as both transmitters and receivers. Other principles of operation include mechanical impact or explosive devices as pulse generators and seismic or accelerometer devices as receivers. Magnetrostrictive transducers are the principal devices that have been used in the pulsing of thin wires used for TDR measurement of temperature. An electromagnetic radio frequency (RF) pulse applied to the magnetostrictive transducer induces an acoustic signal of the same frequency in the wire. The principal advantage of this type device is its ruggedness and capability of producing high powered pulses. In general, piezoelectric transducers convert electric charge to mechanical deformation and vice versa. They are, in general, not as rugged and do not have the peak power capability of magnetostrictive devices. The frequency induced by an electric signal applied to a piezoelectric material is dependent on the frequency of the signal, structure of the piezoelectric material and construction of the transducer. For more general treatment of piezoelectric transducer design and operation, standard texts and references on piezoelectric and ferroelectric transducer materials and design should be consulted.

In general, electrodynamic and electrostatic devices have not been used in high frequency (50 kHz to 5 MHz) TDR measurements involving solids. The mechanical impact and explosive devices are usually used to create low frequency acoustic signals which are then monitored by seismic or accelerometer devices.

There exists another possible measurement technique which can be used in conjunction with acoustic TDR for monitoring temperature but the accuracy, repeatability, and reliability are not usually as good as time base measurements. The measurement basis of the method relies on monitoring and comparing the amplitude of the return echoes to determine the signal attenuation factor as it passes between two acoustic impedance change points. The physical basis of the measurement is that the acoustic attenuation of a given material is a function of temperature as well as other properties of the material and acoustic signal itself. The use of the attenuation technique in conjunction with the normal time base technique may provide additional information about the acoustic media through which the acoustic pulse travels.

### Feasibility

One of the advantages of the technique is that, by its basic nature, it can provide an average temperature through a region by use of a single lead, i.e., no multiple point measurements, requiring multiple leads and averaging are necessary as is the case with thermocouples. It can be packaged as a rugged unit that can withstand a severe and variable environment and it does not require high electrical insulation properties. The principal length of time needed to make a temperature measurement is the transmission time of the acoustic pulse from the transducer to and from the impedance demarcation point. Typically the velocity of sound in liquids is 1,000 to 2,000 meters/sec and for solids is 1,000 to 5,000 meters/sec. Based on these numbers alone, temperatures located over 1,000 ft (300 m) away from the transducer could be monitored in less than 1 sec.

Note: Most current thin wire applications monitor temperatures within the maximum limits of 20 to 30 ft oi the transducer so the selection would have to be made of transducer, frequency of operation, and wire material and dimensions to accomplish the above measurement. The degree of accuracy of the thin wire construction technique depends on the physical dimensions of the wire between the impedance demarcation points, frequency, and the accuracy to which the temperature can be related to the speed of sound. Accuracies of 1% or better should be obtainable.

For the coal gasification or liquefaction processes, reliable measurement and control of high temperatures may require averaged and point temperature information. Averaged temperature information using acoustics can be obtained across a flow channel containing a mixture of coal-oil slurry and gas or along the inside or outside of a length of pipe. These measurements coupled with point measurements may provide heat transfer information on fouling factors or advanced warning of local hot or cold spots where charring or plugging may tend to occur. By the potential adaptation and application of reliable average temperature measurements techniques to the gasification process, it may be possible to obtain information, not otherwise obtainable, for the scaling up of current size plants, e.g., information related to heat transfer for the design of large scale economizers for use as preheaters. Some materials, such as rhenium, when using the ultrasonic thin wire technique, have a potential to withstand high temperatures in hydrogen[4] and carbon environments; there may be other materials that can be used by the same ultrasonic technique that can withstand, even better, the environment in coal processing without encapsulation in a sheath. For some materials it may be possible to weld (or seal) the thin wire directly into or through the wall of the pressure vessel for leak tightness and then activate the sensor by an external transducer to accomplish the temperature measurement.

## 5.0 RECOMMENDATIONS

In order to make automatic control of large-scale coal gasification, liquefaction, and fluidized-bed combustion possible, it will be necessary to begin substantial efforts in the areas of instrumentation development, valve development, and control scheme development as soon as possible. The program schedule should aim for commercial availability of instruments and valves by early 1981, or in five years, and the completion of detailed control schemes by mid 1979 in order to be of use to the first demonstration scale coal conversion plant (COALCON).

## 5.1 Mixed Phase Mass Flow Meters

In order to test and develop techniques for mass flow rate measurement, it is necessary to have available representative flow systems for which the flow rates and makeup of the stream are known and controllable. In order to mockup up all the situations for which flow measurements are needed, it will be necessary to construct two circulating loops: a solid/gas loop and a solid/liquid loop. The systems can operate at atmospheric pressure and provide for only moderate heating of the streams because the physical properties being exploited in the measurements are not expected to depend strongly on pressure or temperature.

The solid/gas flow test facility could consist of two circulating loops, one of pulverized solid material and one of gas, which merge at a pneumatic pickup and diverge in a cyclone separator. Dirty gas from the cyclone would pass through a pump back to the pneumatic pickup. Solid material would fall through the cyclone dip leg to a hopper from which it would be moved by a screw conveyor to the pneumatic pickup. Four lines in the system would be representative of lines in coal conversion and combustion systems: The cyclone up leg (dirty gas flow), the pneumatic transport line (dilute phase solids mass flow), the cyclone dip leg (dilute, actually able to approach dense, phase solids mass flow), and the solids line to the pneumatic pickup (dense phase solids mass flow). The gas flow could be controlled by the pump and measured by an orifice or thermal flowmeter and the solid flow could be controlled and measured by a rotary feeder at the bottom of the hopper. These devices would be suitable here because of the ease of replacement after significant abrasion. The solid/gas flow test facility could be scheduled for completion in five quarters after start of the program.

The solid/liquid flow test facility could be a single loop in which the solid/liquid mixture is pumped from a mixing tank by a positive displacement pump through a test section of pipe and back to the mixing tank. The pump would serve both to control and to measure the flow rate. The solid/liquid flow test facility could also be scheduled for completion about five quarters after start of the program.

Development of new techniques for mixed phase mass flow, described in Section 4.5.1, should be started immediately. Conditions, as summarized in the first three categories of Table II, range from solids densely packed in fluids to gases containing unwanted entrained solid particles. Techniques which show promise for these measurements are acoustic/ultrasonic (passive and active); electromagnetic (eddy current devices for cases where the solid particles are conducting, capacitive density measurements for solid/fluid ratio measurements), time-delayed correlation of noise on spatially separated measurements (ultrasonic transmission, gamma transmission, temperature, etc.), tagging (radiation, electric charge, activation, etc.), and optical scattering (for the entrained particulates case).

Applications studies of electromagnetic flowmeters and thermal flowmeters, described in Section 4.4.1, should be carried out. The estimated five year cost of the program is $2.1 million.

## 5.2 Composition Monitors

Instruments should be developed or improved for on-line composition monitoring of process streams. In cases where elemental composition is desired, the technique of neutron-induced prompt gamma radiation, described in Section 4.5.2, has much to recommend it because of the penetrating power of the neutrons and of the typically high energy prompt gamma rays which permit sampling of the material within a pipe without disturbing the flow.

For detection of the molecular composition of a gas stream, the mass spectrograph and Zeeman effect atomic absorption, described in Section 4.4.2, should be tested in coal process gas streams.

A number of instruments are available and in use now which can analyze for various of the components of interest, but they all require diversion of part of the stream (sampling) to the instrument and cooling, filtering, and drying of the sample before analysis. The analysis itself usually requires five to fifteen minutes for completion. It would be highly desirable to have instruments developed which could truly operate on-line and analyze the material without the preconditioning now required; a more nearly continuous operation and readout would also be an improvement. If it should prove too difficult to eliminate sampling and conditioning, then work should be done to standardize sampling and conditioning procedures in order to make possible a better correlation between the sample composition and the stream composition. The five year cost of this task is estimated to be $2.0 million.

## 5.3 Level Detectors

Acoustic, electrical TDR, and conductivity techniques, described in Section 4.5.3, should be developed for level measurement. Gamma density gauges, described in Section 4.4.3, should be tested for monitoring fluidized bed heights. Estimated five year cost of the task is $1.1 million.

## 5.4 Temperature Sensors

Acoustic TDR, described in Section 4.5.4, should be developed and application of the thermistor strip and radiation pyrometer, described in Section 4.4.4, should be studied. The five year cost is estimated as $750 thousand.

## 5.5 Automatic Control

A single group should be given responsibility for developing mathematical models for all processes, starting from existing studies, and evolving optimal control schemes. The development should be completed by mid 1978 to permit application to the COALCON plant design. Effort after that time would focus on implementing the control schemes and updating them if necessary. The five year cost is estimated at $600 thousand.

### 5.6 Valve Development

Valves should be developed that can perform the actual control function in the coal plants. Materials development will probably be necessary. No cost estimate is given here.

### 5.7 Technical Information Exchange

Communciation among the people working on the various processes should be increased so that they can benefit from one another's experiences and avoid unnecessary duplication of effort.

## 6.0 REFERENCES


1. *Optimization of Coal Gasification Processes,* R & D Report No. 66 - Interim Report No. 2, West Virginia University, (April 1973).

2. T. Hadeishi, D. A. Church, R. D. McLaughlin, B. D. Zak, and M. Nakamura, Lawrence Berkeley Laboratory Report, LBL-1593.

3. L. C. Lynnworth, *Industrial Applications of Ultrasound - A Review, II. Measurements, Tests, and Process Control Using Low-Intensity Ultrasound,* IEEE Transactions on Sonics and Ultrasonics, Vol. SU-22, No. 2, pp. 71-101 (March 1975).

4. B. G. Liptak and R. K. Kaminski, Instrumentation Technology, pp. 49-59 (September 1974).

5. S. J. Bailey, *Single Ultrasonic Beam Measures Liquid Flow,* Control Engineering, p. 53 (December 1974).

6. A. Green, General Manager, Acoustic Emission Technology Corporation, private communication.

7. Instrument Technology, pp. 49-59, (September 1974).

8. T. T. Anderson, A. P. Gavin, and J. P. Bodis, *Acoustic Measurements in the EBR-II Reactor Primary Sodium Tank,* IEEE Trans. on Nuclear Science, NS-22, 671 (1975).

9. L. D. Mullins, W. F. Baldwin, P. M. Berry, *How Detectors Measure Flow-line Sand,* The Oil and Gas Journal, p. 101, (February 3, 1975).

10. A. P. Gavin, T. T. Anderson, and J. R. Janicek, *Sodium Immersible High Temperature Microphone Design Description,* Technical Memo, ANL-CT-75-30, NTIS $9.75.

11. H. B. Karplus, *Ultrasonic Transducer,* Patent Application, ERDA File No. S44,342.

12. Leon Klatt, Oak Ridge National Laboratory, Personal communication (1976).

13. K. Przewlocki and P. Nizegorodcew, *Radiometric Measurements of Hydro-Transport in Industrial Pipe-Lines*, LaHouille Blanche 28, 59 (1973).

14. C. R. Boswell and T. B. Pierce, *Flowrate Determination by Neutron Activation Analysis*, from Modern Developments in Flow Measurement, p. 264, ed. G. C. Clayton, publ. by Peter Peregrinus, Ltd., London (1971).

15. Nuclear Chicago, Industrial Nucleonics, Kay-Ray, Ohmart, Robertshaw, etc.

16. R. L. Randall, *Flow Measurements Using Noise Analysis Techniques*, NAA-SR-MEMO-9787,(1964).

17. M. W. Ashton and P. G. Bentley, *Design Study for On-Line Flow Measurement by Transit Time Analysis of Temperature Fluctuations*, Conference on Industrial Measurement Techniques for On-Line Computers, June 11-13, 1968, London, p. 125 of conference proceedings.

18. F. Boonstoppel, B. Veltman and F. Vergouwen, *The Measurement of Flow by Cross-Correlation Techniques*, Conference on Industrial Measurement Techniques for On-Line Computers, June 11-13, 1968, London, p. 110 of conference proceedings.

19. R. S. Flemons, Special Instrumentation Engineer, Canadian General Electric Company Limited, Personal communication (1975).

20. D. W. Wiegand, *The Eddy Current Flowmeter*, ANL-7554 (1969).

21. V. L. Streeter, *Fluid Mechanics*, 4th Ed., pp. 413-416, McGraw-Hill, New York (1966).

22. W. G. Hyzer, *Particle Measurement*, Research/Development, p. 50, (April 1975).

23. R. L. Parker and F. N. Huffman, *A Microwave Doppler Flowmeter*, from Flow, Its Measurement and Control in Science and Industry, p. 999, ed. by R. B. Dowdell, publ. by Instr. Soc. of America, Pittsburgh (1974).

24. P. D. Iten and J. Mastner, *A Laser Doppler Velocimeter Offering High Spatial and Temporal Resolution*, from Flow, Its Measurement and Control in Science and Industry, p. 1007, ed. by R. B. Dowdell, publ. by Instr. Soc. of America, Pittsburgh (1974).

25. F. M. Shofner, G. Kreikenbaum, H. W. Schmitt, and B. E. Barnhart, In-Situ, *Continuous Measurement of Particulate Size Distribution and Mass Concentration Using Electro-Optical Instrumentation*, presented at The Fifth Annual Industrial Air Pollution Control Conference, Knoxville, Tenn. (April 3-4, 1975).

26. D. Duffey, A. El-Kady, and F. Sentfle, *Analytical Sensitivities and Energies of Thermal-Neutron-Capture Gamma Rays*, Nuclear Instruments and Methods, 80, No. 1, pp. 149-171 (1970).

27. F. E. Sentfle, H. D. Moore, D. B. Leep, A. El-Kady, and D. Duffey, *Analytical Sensitivities and Energies of Thermal Neutron Capture Gamma Rays II,* Nuclear Instruments and Methods, 93, pp. 425-459 (1971).

28. V. J. Orphan, N. C. Rasmussen, and T. L. Harper, *Line and Continuum Gamma-Ray Yields from Thermal Neutron Capture in 75 Elements,* Gulf General Atomic Report GA-10248 (July 31, 1970).

29. R. R. Ruch, H. J. Gluskoter, and N. F. Shimp, *Occurrence and Distribution of Potentially Volatile Trace Elements in Coal: A Final Report,* Illinois State Geological Survey Environmental Geology Notes EGN 72 (August 1974).

30. *Neutron Sources and Applications,* Proceedings of the American Nuclear Society National Topical Meeting, April 19-21, 1971, Augusta, Georgia, Savannah River Laboratory Report CONF-710402, 3 Volumes (August 1971).

31. R. F. Stewart, A. W. Hall, J. W. Martin, W. L. Farrior, and A. M. Poston, *Nuclear Meter for Monitoring the Sulfur Content of Coal Streams,* Bureau of Mines Technical Progress Report 74 (January 1974).

32. Daniel R. Parsignault, Henry H. Wilson, R. Mineski, and S. L. Blatt, *A Prompt Gamma-Ray Coal Analysis System,* Proc. ANS National Topical Conference on Neutron Sources and Applications, Augusta, Georgia, April 19-21, 1971, NTIS CONF-710402, Vol. III, pp. IV-40 - IV-46 (August 1971).

33. C. Varren Parker, Jr., Troy C. Martin, Kenneth R. Blake, and Ira L. Morgan, *Continuous Nuclear Analysis of Bulk Material,* Materials Evaluation, pp. 214-220 (September 1967).

34. Nancy O'Fallon, Dick Duffey, and P. F. Wiggins, *Use of Microgram* $^{252}Cf$ *Sources for Capture Gamma Ray Spectral Standards for Coal Analysis,* Bulletin of the American Physical Society, Series II, Volume 21, No. 1, p. 109, Abstract of a paper given at the APS meeting, New York, New York (January 1976).

35. *Advances in Activation Analysis,* Volume 1, edited by J. M. A. Lenihan and S. J. Thomson (1969); Volume 2, edited by J. M. A. Lenihan, S. J. Thomson, and V. P. Guinn (1972); Academic Press.

36. Kaman Sciences Corporation, Colorado Springs, Colorado.

37. Sam S. Nargolwalla and Edwin P. Przybylowicz, *Activation Analysis with Neutron Generators,* John Wiley & Sons (1973).

38. D. E. Wood, P. L. Jessen, and R. E. Jones, *New Developments in Neutron Activation Systems for Analysis of Oxygen in Steel,* Proceedings of the 1966 Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy (1966).

39. Walter Fuchs and Paul M. Yavorsky, *Bed Level Determination with Time Domain Reflectometry,* Chem. Eng., p. 145 (July 24, 1974).

40. E. H. Carnevale et al., *Ultrasonic Measurement of Elastic Moduli at Elevated Temperatures, Using Momentary Contact*, J. Acoust. Soc. Am., 35, 1883, Abstract F6 (1963); 36, 1678-1684 (1964); *Ultrasonic Determination of Elastic Moduli to 2000°C Using Momentary Contact*, 36, 1999, Abstract I2 (1964); *Ultrasonic Measurements in Solids up to 2800°K*, presented at the 1965 IEEE Ultrasonics Symposium, Boston, Mass., December 1-3, 1965; *Ultrasonic Thermometry and Flaw Detection in Steel Above 2000°F*, presented at the 24th Nat'l Conv. SNT, Phila, Pa., October 19-23, 1964; T. H. Malim, *Ultrasonics Takes Hot Metal Pulse*, Iron Age, 195 (17) 75-77 (April 1965).

41. L. C. Lynnworth, E. P. Papadakis, D. R. Patch, and K. A. Fowler, R. L. Shepard, *Nuclear Reactor Applications of New Ultrasonic Transducers*, IEEE, 1979 Nuclear Science Symposium, IEEE Transactions on Nuclear Science, Vol. NS-18, (February 1971).

42. E. H. Carnevale, L. C. Lynnworth, and G. S. Larson, *Ultrasonic Determination of Transport Properties of Monatomic Gases at High Temperatures*, J. Chem. Phys. 46(8) 3040-3047 (April 15, 1967); E. H. Carnevale, C. Carey, and G. Larson, *Ultrasonic Determination of Rotational Collision Numbers and Vibrational Relaxation Times of Polyatomic Gasses at High Temperatures*, J. Chem. Phys. 47(8) 2829-2835 (October 15, 1967); E. H. Carnevale, G. S. Larson, L. C. Lynnworth, C. Carey, M. Panaro, and T. Marshall, *Experimental Determination of the Transport Properties of High Temperature Gases*, NASA CR-789 (June 1967); E. H. Carnevale et al., Phys. Fluids 10(7) 1495-1467 (July 1967).

## 7.0 ACKNOWLEDGEMENTS

Many people involved in the operation of pilot plants or concerned with the design of large-scale systems for coal conversion or fluidized combustion contributed freely to the information in this report and/or reviewed it for accuracy. Among those who were most helpful are Louis J. Scotti and Haig D. Terzian of the COED Pilot Plant; Frank C. Schora, John W. Loeding, Jack Huebler, and Bill Bair of the HYGAS Pilot Plant; Carl Fink, Irl Zuber, Check Krcil, Marion Vardamon, David Glaser, Phil Boland, Frank Plut, Frank Batug, and Terry Towers of the $CO_2$ Acceptor Pilot Plant; Richard Howell, Robert Stalnaker, and Charles Chao of C. F. Braun Co.; E. O. Curtiss, Jr., Dale Mackey, and Duane Runnels of the Synthane Pilot Plant; Murray Weintraub of the Synthoil unit; Robert Sperhac, Joseph Naylor, Andrew Danhof, Robert Custer, Russ Perrussel, and David Schmalzer of the SRC Pilot Plant; Andrew Bela, Frank Glenn, Eugene Pastrick, and George Hervey of Ralph M. Parsons Co.; Al Jonke, Erwin Carls, Walt Podolski, John Vogel and Bill Swift of the Argonne National Laboratory fluidized bed combustion (FBC) unit; Dr. Ron Hoke, Melvyn Nutkis, and Ray Van Sweringer of the Exxon FBC unit; Michael O'Hagan, Gordon Wade, Rossi Jackson, and Henry Wigton of the Combustion Power FBC unit; R. J. Grace of the BIGAS Pilot Plant; W. C. Corder of the Battelle-Union Carbide unit; Dr. Dale Keairns of Westinghouse; Richard W. Bryers and Thomas W. Shults of Foster Wheeler; Robert G. Shaw, Charles V. Cooper, Cal Watson, Dr. James Vignos, Dr. Peter McCrae, and John Bernard of the Foxboro Co.; George Weth and William Yeich of ERDA-Fossil Energy on the Pope, Evans, and Robbins FBC unit; and Dr. William Eckard, Robert F. Stewart, L. Wayne Shuck, and Neil Coates of the Morgantown Energy Research Center. Their assistance is gratefully acknowledged.

# APPENDIX A

## Data Sheets on Instrumentation Needs from the Argonne National Laboratory Survey

### Grouped According to Measurement Category


| MEASUREMENT CATEGORY | PAGE |
|---|---|
| DENSE PHASE SOLIDS MASS FLOW | A-2 |
| DILUTE PHASE SOLIDS MASS FLOW | A-22 |
| DIRTY GAS FLOW - ENTRAINED SOLIDS MASS FLOW | A-35 |
| C, H, O, S, AND ASH CONTENT OF STREAMS AND VESSELS | A-48 |
| ELEMENTS IN GAS STREAMS | A-68 |
| MOLECULAR COMPOSITION OF GAS STREAMS | A-73 |
| LEVEL OF OIL/WATER INTERFACES | A-81 |
| FLUIDIZED-BED LEVELS AND DENSITIES | A-85 |
| TEMPERATURES IN REACTORS AND COMBUSTORS | A-93 |
| TEMPERATURES OF VESSEL WALLS (HOT SPOTS) | A-99 |
| OTHER INSTRUMENTATION NEEDS | A-103 |

DENSE PHASE SOLIDS MASS FLOW

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Slurry feed mass flow at 1), 2), and 3)

Reason Needed: Control of gasification reaction

Present Method of Determination: density by γ gauge; flow in 2) and 3) by Venturi's; flow in 1) by difference.

Evaluation of Present Method: γ gauge works well, pressure taps on Venturi's must be purged and sometimes plug

Range of Possible Variation: 1 to 5 ft/sec; solids 30 to 50% wt.; liquid $H_2O$ or $C_6H_6$
3 T/hr coal (∿1.2 ft/sec)

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000-1500 psi

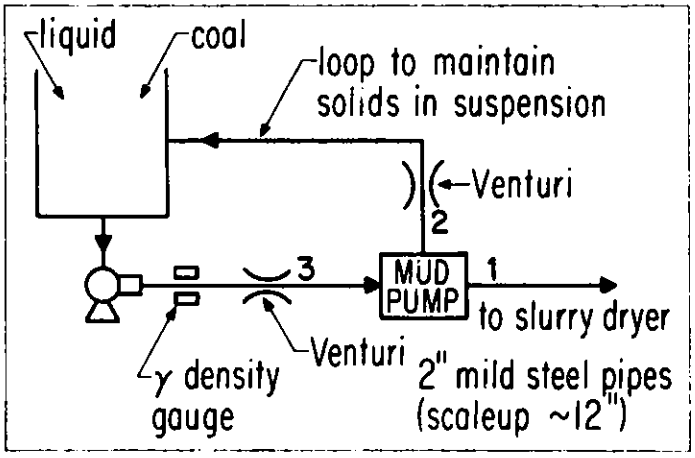
Temperature: ambient

Composition: 30-50% wt. coal in $H_2O$ or $C_6H_6$

Density: 20-35 lbs/ft$^3$ coal, 70 lbs/ft$^3$ slurry

Other: -1/8"(<3mm); avg 60 mesh (400μm)

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Mass flow in the steam-iron hydrogen producer

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1200 psig

Temperature: 650°F

Composition: 50% Fe

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: $CO_2$ Acceptor

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Char feed rate to the regenerator

Reason Needed: Control of regeneration rate

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: ~600 lbs/hr (0.17 lbs/sec)

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: 1500°F

Composition: char

Density:

Other: <6mm

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: BIGAS (Braun-source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Coal feed rate to gasifier

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: $\sim 1.2 \times 10^6$ lbs/hr ($\sim$6.7 ft/sec)

Physical Conditions Associated with the Quantity to be Measured

Pressure: 70-100 atm (1000-1500 psi)

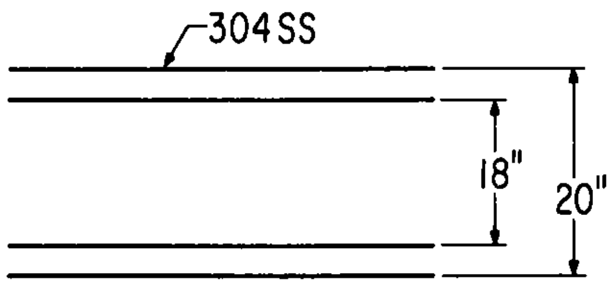
Temperature: amb.

Composition: coal

Density: $\sim 28$ lbs/ft$^3$

Other: 70%-200 mesh (<125μm)

Sketch with Container Dimensions/Materials




## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements: 2-3% tolerable variation in mass flow

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: BIGAS (Foster Wheeler-source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Slag concentration in flow from slag quench vessel

Reason Needed: ____

Present Method of Determination: ____

Evaluation of Present Method: ____

Range of Possible Variation: ____

Physical Conditions Associated with the Quantity to be Measured

Pressure: 200 - 1500 psig

Temperature: 3000°F

Composition: ____

Density: ____

Other: ____

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements: ____

Spatial Limitations on Packaging: ____

Impact of Instrument Malfunction on Process: ____

Accessibility for Maintenance: ____

Reliability and Lifetime Requirements: ____

Ambient Conditions during Operation: ____

Other Considerations: ____

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Slurry injection (C.F. Braun)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids/liquid ratio

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature: $500^{o}F(H_2O$ slurry)

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Solids Mass Flow (Foster-Wheeler source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids mass flow in solid/gas stream in gasifiers

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method: Nothing satisfactory

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 500 psig

Temperature: 800°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids mass flow rate on coal input

Reason Needed: Process control and materials balance

Present Method of Determination: Gravimetric feeder

Evaluation of Present Method: Unsatisfactory because of small belt size, large variation in coal size

Range of Possible Variation: ∿1.1 lbs/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0 psig

Temperature: amb

Composition: raw coal

Density:

Other: size <6mm

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements: 1%

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: ~~10-28-75~~ Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Slurry flow rate

Reason Needed: Process control

Present Method of Determination: 1. Rotameter 2. Target meter 3. Venturi (horizontal)

Evaluation of Present Method: Unsatisfactory because of 1) erosion 2) erosion, temperature sensitivity, inaccuracy 3) plugging of pressure taps

Range of Possible Variation: 3.2 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000 psig-2000 psig

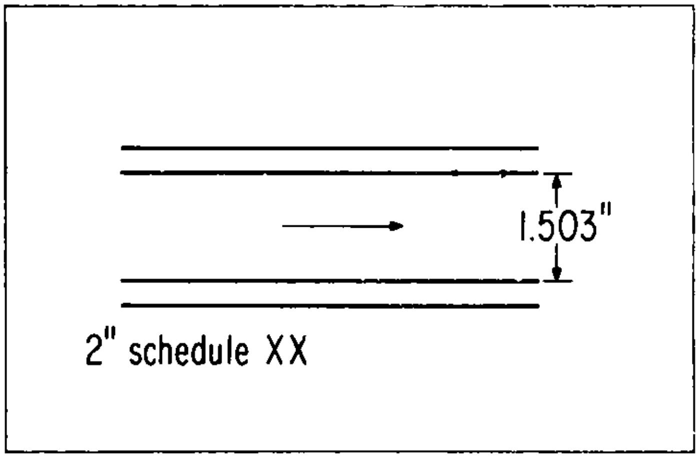
Temperature: amb.

Composition: 1/3 coal 2/3 solvent by weight

Density: ∿20 lbs/ft$^3$ coal ∿70 lbs/ft$^3$ total slurry

Other: ~~80% < 200 mesh (130 μm)~~

Sketch with Container Dimensions/Materials




## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

AP-123 (2-75)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Percent solids in slurry

Reason Needed: Process control

Present Method of Determination: None

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000 psig - 2000

Temperature: amb

Composition: 1/3 coal 2/3 solvent before dissolving

Density: ∿70 lbs/$ft^3$ slurry

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Filter breakthrough - (Percent solids measurement)

Reason Needed: Reduce downtime, control product quality

Present Method of Determination: Lab test of filtrate

Evaluation of Present Method: ~1 hr lag

Range of Possible Variation: ~0 unless breakthrough .01-.001% wt solids (insolubles)

Physical Conditions Associated with the Quantity to be Measured

Pressure: 130 psig

Temperature: 600°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial itations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids flow rate of mineral residue

Reason Needed: Materials balance

Present Method of Determination: Gravimetric

Evaluation of Present Method:

Range of Possible Variation: ∿.25 lbs/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0 psig

Temperature: ambient

Composition: ash, filteraid (diatomaceous earth and asbestos), undissolved coal

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids mass flow rate of SRC output

Reason Needed: Process control & materials balance

Present Method of Determination: Gravimetric feeder

Evaluation of Present Method:

Range of Possible Variation: ∿.6 lbs/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0 psig

Temperature: ambient

Composition: coal-ash & S

solvent refined coal

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Char feed stream solids mass flow rates (dense phase)

6 streams →[1]→[2]→[3]→[4]→

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: ∿20 lbs/ft$^3$ dense phase in standleg
∿1 lb/ft$^3$ in pneumatic transport

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0-15 psig

Temperature:

| | |
|---|---|
| to 1st stage | 3rd-4th 1000°F |
| 1st to 2nd 650°F | From 4th |
| 2nd to 3rd 850°F | 1600°F |

Composition:

Density: ∿20 lbs/ft$^3$

Other: 1/8" to <1µm

bituminous coal

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Synthoil (Foster-Wheeler source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids/liquid/gas mass flow to the reactor

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 4500 psig

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Synthoil (Foster-Wheeler source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Char and ash in product stream

Reason Needed: Quality control of product

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 4500 psig

Temperature: 850°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Liquefaction (Parsons)

Scale. ☐ PDU ☐ Pilot ☒ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Slurry mass flow - coal, char, or ash in oil or gas

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: $\leq$1500 psig

Temperature: $\leq 2000^{\circ}F$

Composition:

Density:

Other: -20 to +200 mesh (1.3mm to 1.3μm)

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

AP-123 (2-75)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Mass flow of Alumina spheres in granular filter system

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: $\sim$60 psi

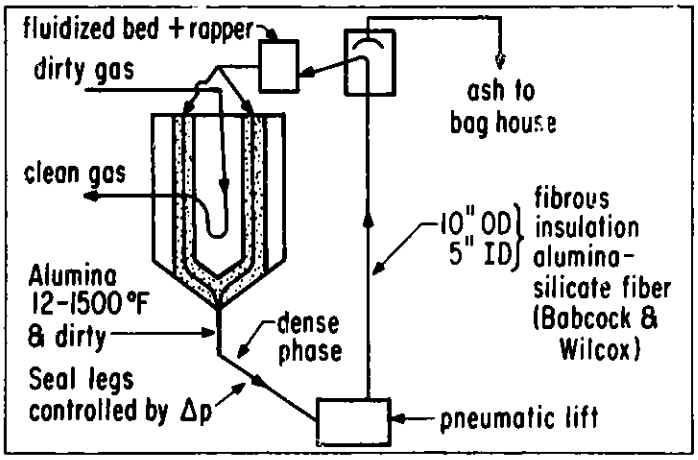
Temperature: 12-1500°F

Composition: $Al_2O_3$ + dirt from gas

Density:

Other: 8-12 mesh (3-2mm)

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Fluid Bed Comb. (Foster Wheeler source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids/gas flow - mass flow rate of solids in dense phase

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method: Nothing satisfactory

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

DILUTE PHASE SOLIDS MASS FLOW

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Overflow mass flow from second stage hydrogasifier to char gasifier

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: ∿0.9 lbs/sec v ≈ 3 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000 psig

Temperature: 1600-1800°F

Composition: char

Density: ∿6 lbs/ft$^3$ (est)

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance: In center of reactor

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Mass flow rate in cyclone dip leg.

Reason Needed: Monitor cyclone operation

Present Method of Determination: None

Evaluation of Present Method:

Range of Possible Variation: $\rho$=6 to 15 lbs/ft$^3$ v=0 to 10 ft/sec up or down

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000 psi

Temperature: 500 to 600$^{\circ}$F

Composition:

Density: 6 to 15 lbs/ft$^3$ solids in gas

Other: size 100 mesh (250$\mu$m) to 1$\mu$m

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance: ~100 ft vertical exposed pipe

Reliability and Lifetime Requirements:

Ambient Conditions during Operation: exposed to outside

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: BIGAS (C.F. Braun source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Char mass flow in cyclone dip leg (4 of them)

Reason Needed: Process control

Present Method of Determination: Thermal flowmeter

Evaluation of Present Method:

Range of Possible Variation: $\sim 2.23 \times 10^5$ lbs/hr ($\sim$3.3 ft/sec)

Physical Conditions Associated with the Quantity to be Measured

Pressure: $\sim$1500 psi

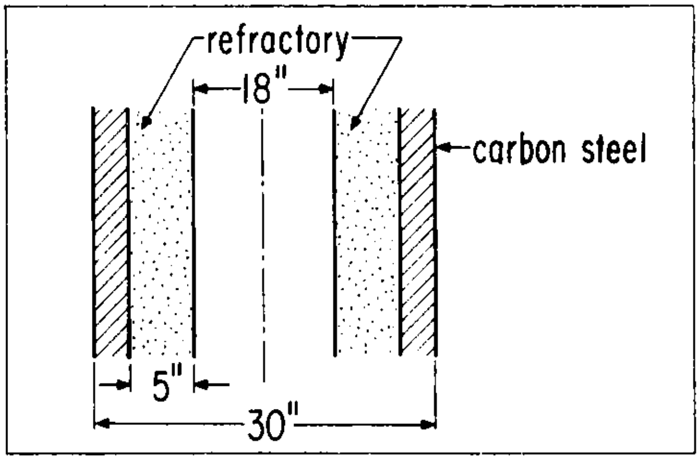
Temperature: 800 - 1000$^{\circ}$F

Composition: 83.1%C, 16.2% ash, 0.7% $H_2O$ by wt.

Density: 10.5 lbs/ft$^3$

Other: 70%-200 mesh (<125μm)
110 ft drop

Sketch with Container Dimensions/Materials




## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Char feed solids mass flow rate (pneumatic transport phase) 6 streams

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method: ∿1 lb/ft$^3$

Range of Possible Variation: ∿40 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0-15 psig

Temperature: amb. - 1600$^\circ$F

Composition: char

Density: ∿1 lb/ft$^3$

Other: <3mm

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations: See alternate measurement in dense phase

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: ANL

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Limestone feed mass flow - pneumatic transport

Reason Needed: Process control

Present Method of Determination: Weigh hopper

Evaluation of Present Method: Fair, but not applicable to large scale systems with multiple feed lines

Range of Possible Variation: ~10 lbs/hr, 70 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150

Temperature: amb

Composition: limestone

Density: 14-17 lbs/$ft^3$

Other: .2 - 2 mm

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: ANL

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Coal feed mass flow -pneumatic transport

Reason Needed: Process control

Present Method of Determination: Weigh hopper + pocket feeder

Evaluation of Present Method: Fair, but not applicable to large scale systems with multiple feed lines

Range of Possible Variation: ∿25 lbs/hr, 70 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150

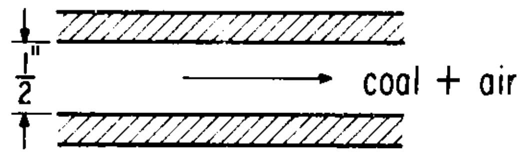
Temperature: amb.

Composition: coal

Density: 36-43 $lbs/ft^3$

Other: <2mm

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Coal/dolomite mixture mass flow rate in air pneumatic feeder to combustor

Reason Needed: Process control

Present Method of Determination: Gravimetric

Evaluation of Present Method:

Range of Possible Variation: 40-50 lbs/min solids, 50-60 lbs/min air (~50 ft/sec)

Physical Conditions Associated with the Quantity to be Measured

Pressure: 4 atm (60 psi)

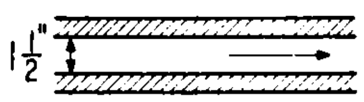
Temperature: Ambient

Composition: 2/3 coal 1/3 dolomite by weight

Density:

Other: Single feed point - multiple on larger units

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids mass flow rate in cyclone dip leg

Reason Needed: Process control, turbine protection

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: 12-17 lbs/min

Physical Conditions Associated with the Quantity to be Measured

Pressure: ~60 psi

Temperature: 1450°F

Composition: $CaSO_4$ + ash

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Ash from alumina spheres in cleanup section of granular filter system

Reason Needed: Process control, turbine protection

Present Method of Determination: Impactors

Evaluation of Present Method: Not on-line, continuous

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psi

Temperature: 12-1500$^{o}$F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

AP-123 (2 75)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: EXXON

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Mass flow in dip leg of cyclone separator-crushed sulfated limestone

Reason Needed: Process control

Present Method of Determination: 1) Sight glasses 2) Thermocouples

Evaluation of Present Method: 1) & 2) Unsatisfactory

Range of Possible Variation: 30-60 $lbs/ft^3$, ~70 lbs/hr

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: 1700°F

Composition: sulfated limestone + ash

Density: 30-60 $lbs/ft^3$

Other: <3mm

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date 10-28-75 Process: EXXON

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Coal-limestone feed mass flow rate

Reason Needed: Process control, materials balance

Present Method of Determination: 1) Load cells on injector hopper 2) Passive acoustic

Evaluation of Present Method: 1) Unsatisfactory for short term fluctuations or multiple lines from hopper 2) Somewhat helpful, but frequency analysis should be investigated

Range of Possible Variation: ∼480 lbs/hr coal ∼100 lbs/hr dolomite ∼60 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 10 atm (150 psig)

Temperature: amb

Composition: coal, dolomite, air

Density: ∼2 lbs/ft$^3$

Other: <3mm

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

AP-123 (2-75)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Fluid Bed Combustion (Foster Wheeler-source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids mass flow in dilute phase

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method: Nothing satisfactory

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

DIRTY GAS FLOW - ENTRAINED SOLIDS MASS FLOW

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: $CO_2$ Acceptor

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids mass flow rate of the product gas stream

Reason Needed: Materials balance, gas cleanup equipment protection

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: ∿100 lbs/$10^5$SCF = 7 grains/SCF ±100%

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: 1500°F

Composition: char, acceptor, ash

Density: 7 grains/scf

Other: <60μm size

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: $CO_2$ Acceptor

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Solids loading of the recycle regenerator gas

Reason Needed: Prevent accumulation of recirculating acceptor fines

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Gas cleanup (C.F. Braun)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Particulate loading of gas streams

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: $\leq$1000 psig

Temperature: 1000-2000$^{o}$F

Composition: char, ash

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Flow rate in $H_2$ recycle stream in the oil hydrotreating plant

Reason Needed: Materials balance

Present Method of Determination: Pump displacement & rpm

Evaluation of Present Method:

Range of Possible Variation: ~25000 SCF/hr

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Liquefaction (Parsons)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Dust laden gas flow

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: ≤1500 psi

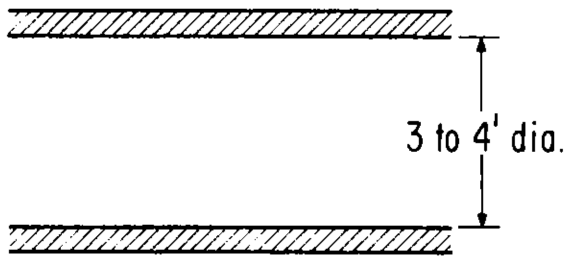
Temperature: >1800°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials




## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: ANL

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Concentration and size of solid particles in gases

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: .1 grain/SCF
$\geq 2\mu m$ must be $\leq .01$ grain/SCF

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature:

Composition:

Density:

Other: $\geq 99\%$ of particles $\geq 2\mu m$ must be removed

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

AP 123 (2 75)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Particulate monitor for stack gas

Reason Needed: Monitor for failure of particle cleanup for turbine protection

Present Method of Determination: 1) Capacitive impurgement measurement

Evaluation of Present Method: 1) Problems with pressure across microphone & temperature

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: ∿0 psig

Temperature: 4-500°F (Now 900°F because of old turbine)

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Particulate loading in flue gas to turbine

Reason Needed: Turbine protection

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: .1 to 1 lb/$10^6$ Btu (∿.2 grain/SCF)

Physical Conditions Associated with the Quantity to be Measured

Pressure: 4 atm (60 psig)

Temperature: 1600$^\circ$F

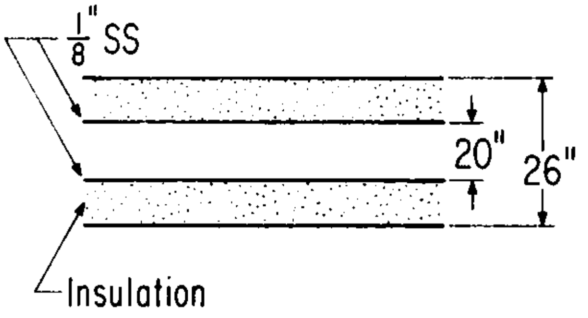
Composition: Ca, Si, Fe, Al

Density:

Other: < 5μm most < 1μm

50% pt 0.7μm

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: EXXON

Scale ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Particulate loading of combustion gas

Reason Needed: Protection of turbine blades, materials balance

Present Method of Determination: Impactor sampler

Evaluation of Present Method: Unsatisfactory - not continuous, sampling questionable

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: 1700°F

Composition: char, ash, dolomite

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: PER

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Particulates in flue gas

Reason Needed: Process control, environmental protection

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition: $CaSO_x$, char

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Pressurized FBC (Westinghouse-source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Particulate loading of flue gas

Reason Needed: Turbine protection

Present Method of Determination: 

Evaluation of Present Method: 

Range of Possible Variation: 

Physical Conditions Associated with the Quantity to be Measured

Pressure: 

Temperature: 

Composition: 

Density: 

Other: 

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements: 

Spatial Limitations on Packaging: 

Impact of Instrument Malfunction on Process: 

Accessibility for Maintenance: 

Reliability and Lifetime Requirements: 

Ambient Conditions during Operation: 

Other Considerations: 

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Fluid Bed Combustion (Foster-Wheeler-source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Particulate loading of gas

Reason Needed: Turbine protection

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

C, H, O, S, AND ASH CONTENT OF STREAMS AND VESSELS

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: Coal preparation (C.F. Braun)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: C, H, O content of coal on-line or even rapid lab technique

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition: coal

Density:

Other: 20-25000 T/day

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Carbon-to-ash ratio in char stream from 1st stage to 2nd stage hydrogasification

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000 psi

Temperature: 1200-1400$^{o}$F

Composition: char

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Carbon-to-ash ratio in char stream from 2nd stage hydrogasifier to char gasification

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000 psig

Temperature: 1600-1800°F

Composition: char

Density: 6 lbs/ft³ (est.)

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance: In center of reactor

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials N.O. Date 10-28-75 Process HYGAS

Scale ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured Carbon-to-ash ratio in the refuse char

Reason Needed Process control

Present Method of Determination

Evaluation of Present Method

Range of Possible Variation

Physical Conditions Associated with the Quantity to be Measured

Sketch with Container Dimensions Materials

Pressure

Temperature 1800-1900°F

Composition

Density

Other

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements

Spatial Limitations on Packaging

Impact of Instrument Malfunction on Process

Accessibility for Maintenance

Reliability and Lifetime Requirements

Ambient Conditions during Operation

Other Considerations

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials N.O. Date 10-28-75 Process: HYGAS

Scale ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured Sulfur content in the refuse char

Reason Needed Process control

Present Method of Determination

Evaluation of Present Method

Range of Possible Variation

Physical Conditions Associated with the Quantity to be Measured

Pressure

Temperature 18-1900°F

Composition

Density

Other

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements

Spatial Limitations on Packaging

Impact of Instrument Malfunction on Process

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

AP 123 (2 78)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Stream composition in the steam-iron hydrogen producer Fe,Al,Si

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition: ~50% Fe

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: $CO_2$ Acceptor

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Char/acceptor ratio in the gasifier and location of char-acceptor interface

Reason Needed: Gasification reaction rate control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

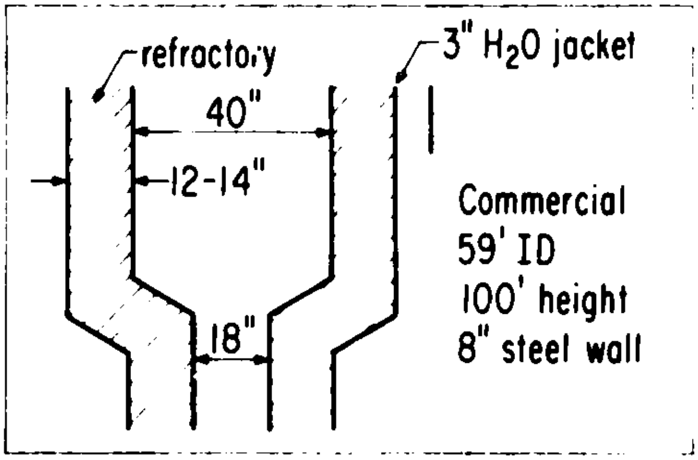
Temperature: 1500°F

Composition: char/limestone

Density:

Other:

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: $CO_2$ Acceptor

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Chemical composition of materials in gasifier and regenerator

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: 1500°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: ~~BIGAS~~ (C.F. Braun, source)

Scale ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Carbon to ash ratio in ash slurry

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 200-1500 psig

Temperature: 1000°F

Composition:

Density:

Other:

Sketch with Container Dimensions Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Volatile content of coal and char

Reason Needed: Process control - agglomerating temperature related to volatile content

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0-15 psig

Temperature: amb. - 1600°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations: More important to this process than fixed C

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials N.O. Date 11-4-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: $O_2$ content in the first stage reactor (pretreater)

Reason Needed: $O_2$ must be sufficient to prevent caking, but decreases oil yield

Present Method of Determination:

Evaluation of Present Method: Unsatisfactory

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: <5 psig

Temperature: 650°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Sulfur content in process streams

Reason Needed: Process control, environmental protection

Present Method of Determination: Laboratory analysis of samples

Evaluation of Present Method: Not on line

Range of Possible Variation: 0.1 - 10%

Physical Conditions Associated with the Quantity to be Measured

Pressure: $\leq$1000 psig

Temperature: $\leq 600^{o}F$

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: ANL

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: S in regenerated limestone stream (future)

Reason Needed: Process control, environmental protection

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: ∿150 psig

Temperature: ∿1700°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: ANL

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Composition in gas/solid process streams C, $H_2O$, ash, S

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 50-150 psig

Temperature: amb.-1700$^{o}$F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: EXXON

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Sulfur content of regenerated limestone (future)

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: $\sim 1700^{\circ}F$

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: On line Ca, Ca/S, perhaps S & Fe content of dolomite recirculating loop (future)

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psig

Temperature: $\sim 1700^{\circ}F$

Composition: Dolomite

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-5-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: On line Ca, Ca/S, perhaps S & Fe content in cyclone dip leg.

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psig

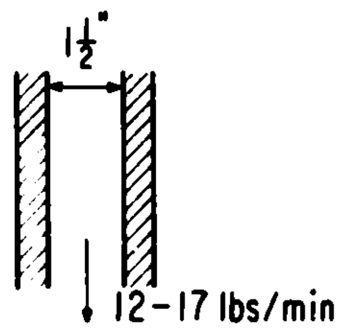
Temperature: 1450$^{o}$F

Composition: sulfated dolomite, ash

Density:

Other:

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-5-75 Process: PER (W. Yelch-ERDA-FE)

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Carbon to ash ratio in stack precipitators - especially from carbon burnup cell

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0 psig

Temperature: $\leq 2000^{\circ}F$

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

AP 123 (2 75)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-5-75 Process: PER

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Carbon to ash ratio on input to carbon burnup cell

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0 psig

Temperature: $1550^{o}F$

Composition: char

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

AP 123 (2-75)

# ELEMENTS IN GAS STREAMS

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: ~~Methanation~~
(C. F. Braun - Source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: PPM detection of metallic elements Ni,Fe,V

Reason Needed: Protection of catalyst

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: EXXON

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Trace elements in effluents (Pb,Hg)

Reason Needed: Environmental protection

Present Method of Determination: None

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: ~0 psig

Temperature: <1000°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-5-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Alkali vapors in turbine input

Reason Needed: Turbine protection by control of additives to tie alkalis up in particles

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: ppb range

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psig

Temperature: 1450°F

Composition: $Na^+$, $K^+$

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-5-75 Process: Pressurized FBC (Westinghouse)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Alkali ion content of flue gas

Reason Needed: Turbine protection

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: $\lesssim$165 psig

Temperature: $\lesssim$2000

Composition: $Na^+$, $K^+$

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# MOLECULAR COMPOSITION OF GAS STREAMS

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 10-28-75 Process: $CO_2$ Acceptor

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Gas molecular composition

Reason Needed: Process control and materials balance

Present Method of Determination: Gas chromatographs

Evaluation of Present Method: Unsatisfactory because of calibration difficulty, fouling by entrained fines

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: 1500°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: $CO_2$ Acceptor

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Steam content of product gas

Reason Needed: Materials balance

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: 20-40% by volume

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

Temperature: $1500^{\circ}F$

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

AP-123 (2-75)

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Molecular form of S in product gas, $H_2S$, COS

Reason Needed:

Present Method of Determination: None

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 10-15 psig

Temperature: $1600^oF$

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: $SO_2$ in stack gas

Reason Needed: EPA requirements

Present Method of Determination:

Evaluation of Present Method: Unreliable

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0 psig

Temperature: $\leq 1600^{\circ}F$

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements.

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-4-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Gas composition - hydrogen recycle

Reason Needed: Process control, materials balance

Present Method of Determination: 1) On-line gas chromatograph, Beckman 6700, 2) Infrared CO, $CO_2$ (Beckman), 3) $O_2$ (lockwood & McLorie)

Evaluation of Present Method: 1,2,3 Satisfactory results if sample remains gas at ambient conditions, but time lag in analysis and calibration are disadvantages

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1700 psig

Temperature: 100°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials N.O. Date 11-4-75 Process EXXON

Scale ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured Gas composition $NO_x$, $SO_2$, CO, $O_2$

Reason Needed Process control, environmental protection

Present Method of Determination 1) Infrared 2) Polaragraphic

Evaluation of Present Method 5 minute cycle, continuous sampling, periodic update by recorder, sample questionable after cleanup, cooling (1500°F to 200°F), and moisture removal

Range of Possible Variation

Physical Conditions Associated with the Quantity to be Measured

Pressure 150 psig

Temperature 1500°F

Composition ≤ 1000 ppm

Density

Other

Sketch with Container Dimensions Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation

Other Considerations

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-5-75 Process: CPU

Scale ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Molecular composition of gas $SO_2$, $NO_x$, $SO_3$, CO, $CO_2$, hydrocarbons, $O_2$, HCl

Reason Needed: Process control, environmental protection

Present Method of Determination: flame ionization, infrared, wet chemistry (nothing at all for HCl

Evaluation of Present Method: Nothing close to being acceptable with problems of sampling w. $H_2O$ and particle removal and cooling and depressurization

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psig

Temperature: 1450°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

LEVEL OF OIL/WATER INTERFACE

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials N.O. Date 11-5-75 Process HYGAS

Scale ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Oil-water interface level in separator for water and oil condensed out of the product gas

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density: oil lighter than $H_2O$

Other:

Sketch with Container Dimensions Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials N.O. Date 11-5-75 Process COED

Scale [ ] PDU [x] Pilot [ ] Demo [ ] Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Oil-water interface level in decanter (where condensed liquids from process separate)

Reason Needed: Separate oil from water

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure

Temperature

Composition

Density: Specific gravity .98 light 1.1 heavy

Other

Sketch with Container Dimensions Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

[ ] Low [ ] Medium [x] High [ ] Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials N.O. Date 11-5-75 Process: SRC

Scale ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Level of water-oil interface

Reason Needed: Process control

Present Method of Determination: 1) Floats 2) Level glass

Evaluation of Present Method: All unsatisfactory because of similarity of oil and water in 1) density, 2) appearance

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other: Conductivity of oil & water differ greatly

Sketch with Container Dimensions Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

FLUIDIZED-BED LEVELS AND DENSITIES

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-5-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Fluid bed levels in hydrogasifier

Reason Needed: Process control

Present Method of Determination: Differential pressure

Evaluation of Present Method: Fair, would like greater reliability and accuracy

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000-1500 psig

Temperature: 16-1800°F

Composition: char

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Fluid bed levels in the steam-iron hydrogen producers (future).

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1200 psi

Temperature: 650°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: COED

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Fluidized bed heights and densities

Reason Needed: Process control - avoid carryover

Present Method of Determination: Differential pressure between top and bottom

Evaluation of Present Method: Works fairly well, could be improved

Range of Possible Variation:

Fluidizing gas ~1 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0-15 psig

Temperature 650-1600°F

Composition: char

Density

Other: Vessel walls ~1/2", I.D's

1)6', 2)5', 3)4.5', 4)2'-4'

In commercial-refractory lining of 3) & 4)

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: ANL

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Fluidized bed height and density

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: ∿10 ft

Physical Conditions Associated with the Quantity to be Measured

Pressure: 10 atm

Temperature: 1500-1700°F

Composition: Ca/S ≈ 1.2 to 1.9 wt.

Density:

Other: $v_{flu} \lesssim 10$ ft/sec

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: EXXON

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Fluidized bed height in combustor (& regenerator)

Reason Needed: Process control

Present Method of Determination: Differential pressure

Evaluation of Present Method: Satisfactory except for plugging pressure taps

Range of Possible Variation: v fluidizing (superficial) 10 ft/sec in comb., 5 ft/sec in reg.

Physical Conditions Associated with the Quantity to be Measured

Pressure: 150 psig

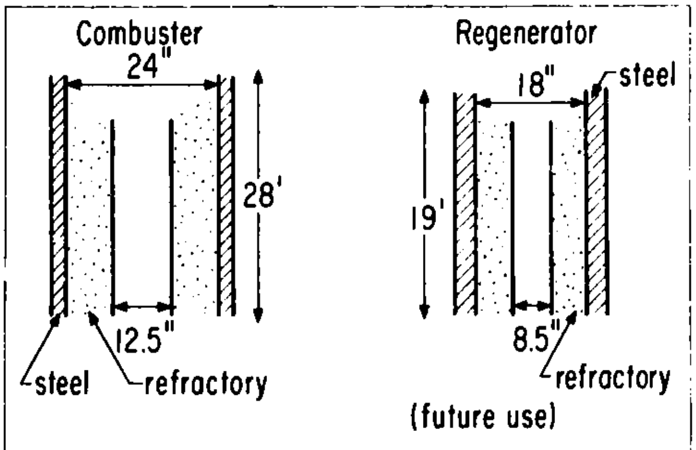
Temperature: 1700°F comb; 2000°F reg.

Composition: Char/limestone ∿5/1 wt in comb.; sulfated limestone in reg.

Density:

Other:

Sketch with Container Dimensions/Materials




## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Fluidized bed levels

Reason Needed:

Present Method of Determination: Differential pressure

Evaluation of Present Method: Alright except for plugging of taps and leaks in sensing lines

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psig

Temperature: 1450°F

Composition: coal/dolomite ∿ 2/1 wt in combustor

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: Fluid bed combustion (Foster-Wheeler source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Fluidized bed level measurement

Reason Needed:

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☒ Medium ☐ High ☐ Very High

# TEMPERATURES IN REACTORS AND COMBUSTORS

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: BIGAS (C.F. Braun source)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Temperature of stage 1 gasifier

Reason Needed: Process control, safety

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: ~3000°F, cannot deviate >200°F from set pt.

Physical Conditions Associated with the Quantity to be Measured

Pressure: ~~1650 psig~~

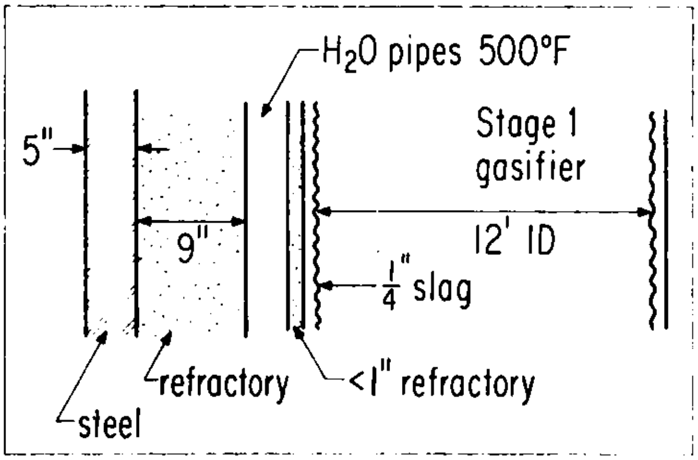
Temperature: ~~3000°F~~

Composition: ~~char~~

Density:

Other:

Sketch with Container Dimensions/Materials




### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: BIGAS (C.F. Braun-source)

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Temperature in gasifier with rapid response for $\Delta T \sim 200^{\circ}F$

Reason Needed: Process control, safety

Present Method of Determination: Thermocouples

Evaluation of Present Method: Response too slow

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☐ High ☒ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: HYGAS

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Temperature of stage 2 hydrogasifier

Reason Needed: Process control, safety

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000-1500 psig

Temperature: 1800°F

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: EXXON

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Bed temperature in combustor (& regenerator when operational)

Reason Needed: Process control, safety

Present Method of Determination: Thermocouples (sheathed)

Evaluation of Present Method: Satisfactory except for frequent failure ∿20-30 hrs avg. time

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured C=combustor R=regenerator

Sketch with Container Dimensions/Materials

Pressure: 10 atm (150 psig)

Temperature: 1700°F(C)2000°F(R)

Composition:

Density:

Other:

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: PER

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Temperature in furnace

Reason Needed: Process control

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation: 1700-2000$^0$F set pt. maintained to ±200$^o$F

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature: 1550$^0$F except 2000$^o$F in ~~carbon burnup cell~~

Composition:

Density:

Other: oxidizing atm.

~minute response

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

TEMPERATURE OF VESSEL WALLS (HOT SPOTS)

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: Gasification (C.F. Braun)

Scale: ☐ PDU ☐ Pilot ☐ Demo ☒ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Hot spots on unjacketed vessels

Reason Needed: Safety

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: CPU

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Hot spots on and in vessels

Reason Needed: Safety

Present Method of Determination: 1) Thermocouples on skin 2) Temperature-sensitive paint

Evaluation of Present Method: 1) Limited by area to be covered 2) Slow and strongly affected by ambient conditions

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psig internal

Temperature: $1450^{\circ}$F internal

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: EXXON

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: 1) Integrity of ceramic liner of combustor or 2) location of hot spots

Reason Needed: Protection of vessel, safety

Present Method of Determination: 1) None 2) Temperature-sensitive paint

Evaluation of Present Method: 2) Too slow, depends also on external conditions

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: ~~150 psig internal~~

Temperature: 1700-2000°F internal

Composition:

Density:

Other.

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

OTHER INSTRUMENTATION DEFICIENCIES

## SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

### CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Pressure in vessels & heaters (real problem)

Reason Needed: Process control

Present Method of Determination: Bourdon tubes, moving diaphragm

Evaluation of Present Method: Unsatisfactory because of plugging and solidification

Range of Possible Variation: 1000-2000 psi

Physical Conditions Associated with the Quantity to be Measured

Pressure: 1000-2000 psig

Temperature:

Composition:

Density:

Other:

Sketch with Container Dimensions/Materials

### RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations. Process streams solidify at ~400°F

### PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Liquid flow of dirty streams

Reason Needed: Process control

Present Method of Determination: 1) Turbine meter 2) Orifice meter

Evaluation of Present Method: 1) Unsatisfactory, bearings fouled 2) Fairly satisfactory, but erosion problem

Range of Possible Variation: 0.1 to 10 ft/sec

Physical Conditions Associated with the Quantity to be Measured

Pressure: 0-1000 psig

Temperature: amb - $850^{o}F$

Composition: solid particles $< 25 \mu m$

Density:

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: ~~11-6-75~~ Process: SRC

Scale: ☐ PDU ☒ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Location of plug due to solidification of liquid process stream

Reason Needed: Reduce down time when plug occurs

Present Method of Determination: None

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure:

Temperature:

Composition:

Density

Other:

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging

Impact of Instrument Malfunction on Process

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

# SURVEY OF COAL PROCESS INSTRUMENTATION

Initials: N.O. Date: 11-6-75 Process: CPU

Scale: ☒ PDU ☐ Pilot ☐ Demo ☐ Commercial

## CHARACTERIZATION OF THE MEASUREMENT

Quantity to be Measured: Abrasive wear on pipes and deflector in alumina bead circulation in granular filter

Reason Needed: Safety

Present Method of Determination:

Evaluation of Present Method:

Range of Possible Variation:

Physical Conditions Associated with the Quantity to be Measured

Pressure: 60 psi

Temperature: 12-1500°F

Composition: $Al_2O_3$ + ash

Density

Other

Sketch with Container Dimensions/Materials

## RESTRICTIONS ON THE INSTRUMENT

Accuracy and Precision Requirements:

Spatial Limitations on Packaging:

Impact of Instrument Malfunction on Process:

Accessibility for Maintenance:

Reliability and Lifetime Requirements:

Ambient Conditions during Operation:

Other Considerations:

## PRIORITY FOR DEVELOPMENT OF INSTRUMENTATION FOR THIS MEASUREMENT IN THIS PROCESS

☐ Low ☐ Medium ☒ High ☐ Very High

APPENDIX B

# EVALUATION OF
# CURRENT INSTRUMENTATION PRACTICES
# IN COAL CONVERSION PLANTS

FLUOR PIONEER INC.
200 WEST MONROE STREET
CHICAGO, ILLINOIS 60606
TELEPHONE: (312) 368-3500

| | Page |
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| List of Instruments Considered Suitable for Scale Up in the COED, $CO_2$ Acceptor, Hygas, SRC, and Synthane Processes . . . . . . . . . . . . . . | B-15 |
| List of Instruments Considered Questionable or Unsuitable for Scale Up in the COED, $CO_2$ Acceptor, Hygas, SRC, and Synthane Processes . . . | B-91 |

Fluor Pioneer Inc. Project #10-0407

Prepared By: Lawrence E. Ryan. Date Oct. 20, 1975

Approved By: Wm G. Dentsl Date Oct 20 1975

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## 1. INTRODUCTION

This report presents the results of a study performed by Fluor Pioneer Inc. in cooperation with Dr. N. M. O'Fallon of Argonne National Laboratory. The purpose of the study was to perform the first and second phase of a four-phase ERDA sponsored program undertaken by Argonne National Laboratory. That program seeks to ascertain areas of instrumentation requiring research and development effort for application to large-scale coal conversion projects. Further information about that program can be found in the March 26, 1975 letter from Mr. F. W. Foster, of Argonne National Laboratories to Fluor Pioneer Inc.

The first two phases of this program required review of instrumentation currently applied to five pilot plants, each plant utilizing a different coal conversion technique. The large number of instrument devices involved and the amount of information applicable to each device suggested the mechanism of utilizing a computerized data record for handling and manipulation system for this study.

Fluor Pioneer Inc.'s computerized Instrumentation Data Record System was adapted to the purpose of this study. The basis of this system is that a record is created for each device reviewed, containing up to fifteen items of information about that device. The system can be operated in a search mode for records with entries which satisfy selected logical statements. This feature was utilized in this study to pin-point data which responds to the basic questions posed by the first two phases of this program.

## 2. SUMMARY

2.1 The first and second phases of the ERDA program are:

2.1.1 Evaluation of the projected usefulness in demonstration and commercial scale plants of instrumentation currently used in pilot and sub-pilot scale systems.

2.1.2 Evaluation of the projected usefulness in demonstration and commercial scale plants of commercial instrumentation that is currently available or under development but not now used in pilot or sub-pilot scale systems.

2.2 The results of our study are summarized as:

2.2.1 Instrumentation now in use on pilot and sub-pilot scale systems generally are suitable for use in demonstration and commercial scale plants, except for:

2.2.1.1 Level of fluidized beds

2.2.1.2 Flow of slurries and aerated slurries

2.2.1.3 Level of slurries and aerated slurries

2.2.1.4 Passage of or location of interfaces in oil/water/tar vessels or lines.

2.2.2 Commercial instrumentation currently available, or under development, not now used in pilot and sub-pilot scale systems may require further research and development to satisfy the exceptions given in paragraph 2.2.1 above.

2.3 As a result of our study and experience, we make the following observations and recommendations for your consideration:

2.3.1 Documentation of instrumentation schemes and characteristics appear to be deficient in the five plants in this study. We recommend that standards for this documentation be developed and enforced on future projects relating to ERDA sponsored development processes, including requirements for updating documentation to accurately reflect post-commissioning revisions.

2.3.2 Our observations and recommendations about specific problems are given in Section 6 of this report.

## 3. INTERPRETATION OF DATA RECORDS

Two sample data records are presented here for explanatory purposes. The date in the upper right-hand corner of the record is the date the record was printed. The Device ID Number is also printed in the upper right-hand corner. Fifteen types of information may be entered into the record. These are listed under the column heading "Description". The information actually contained in the record is listed under the column heading "Information", the date the record was created is listed as "Original Entry Date", and the date of the last revision to the record is listed as "Revision Date". Asterisks in the left-hand column indicates the items of information changed during the last revision. The remainder of the record format is self-explanatory.

The information entered into "Review (Yes/No)" is to be interpreted as follows:

NO means no further review of this instrument is required as our evaluation shows this application should be acceptable in scaled-up plants.

YES means further review was required to establish the evaluation. The area identified as worthy of further review is then found in the next line of the record.

The sample data record presented here illustrate the above discussions.

## 4. DISCUSSION

4.1 A total of 4,569 instruments were examined for potential problems in large scale coal conversion application. Of these, 92.6% were evaluated as being of no foreseeable problem in scale-up application. The remaining 7.4% required further examination before a meaningful evaluation could be made.

4.2 Process Application:

Instruments shown on Process Flow Sheets which were reviewed, were well applied within the limits of technology when purchased. However, in each case, the instrument's function was carefully weighed against process requirements.

FILE D4071 INFORMATION RETRIEVAL SYSTEM 09/08/75
REQUEST 888

ARGONNE NATIONAL LABORATORY-ERDA COAL CONVERSION INST.REVIEW

DEVICE I.D. NO. PI 210

| UPDATE | ITEM | LINE | DESCRIPTION | INFORMATION |
|---|---|---|---|---|
| | 01 | 01 | ORIGINAL ENTRY DATE | 06/25/75 |
| ** | 02 | 01 | REVISION DATE | 07/17/75 |
| | 05 | 01 | PLANT NAME | COED |
| | 06 | 01 | PLANT TYPE | COAL LIQUEFACTION |
| | 07 | 01 | FLOW SHEET | BKC 2383-111-4 |
| | 08 | 01 | MEASUREMENT NAME | FIRST STAGE PYROLYZER CYCLONE B PRESSURE INDICATOR |
| | 11 | 01 | SERVICE RECORD | |
| | 12 | 01 | MANUFACTURER/MODEL | |
| ** | 15 | 01 | REVIEW (YES/NO) | NO |
| | 16 | 01 | YES/REASON/CODE | |
| | 17 | 01 | NO/REASON/CODE | |
| | 18 | 01 | PERFORMANCE | |
| | 19 | 01 | PERFORMANCE ASSESSME | |
| | 21 | 01 | PHYSICAL PRINCIPAL R | |
| | 25 | 01 | COMMENTS | |



FILE D4071 INFORMATION RETRIEVAL SYSTEM 09/08/75
REQUEST 888

ARGONNE NATIONAL LABORATORY-ERDA COAL CONVERSION INST.REVIEW

DEVICE I.D. NO. PDT 211

| UPDATE | ITEM | LINE | DESCRIPTION | INFORMATION |
|---|---|---|---|---|
| | 01 | 01 | ORIGINAL ENTRY DATE | 06/25/75 |
| ** | 02 | 01 | REVISION DATE | 07/17/75 |
| | 05 | 01 | PLANT NAME | COED |
| | 06 | 01 | PLANT TYPE | COAL LIQUEFACTION |
| | 07 | 01 | FLOW SHEET | BKC 2383-111-4 |
| | 08 | 01 | MEASUREMENT NAME | FIRST STAGE PYROLYZER FLUID BED MID LVL D/P XMTR |
| | 11 | 01 | SERVICE RECORD | |
| | 12 | 01 | MANUFACTURER/MODEL | |
| ** | 15 | 01 | REVIEW (YES/NO) | YES |
| ** | 16 | 01 | YES/REASON/CODE | CHECK PROC COND |
| | 17 | 01 | NO/REASON/CODE | |
| | 18 | 01 | PERFORMANCE | |
| | 19 | 01 | PERFORMANCE ASSESSME | |
| | 21 | 01 | PHYSICAL PRINCIPAL R | |
| | 25 | 01 | COMMENTS | |

4.3 Appropriateness of Measurement Application:

This second evaluation gave rise to some observations about instrument application techniques which, though acceptable for pilot or sub-pilot plants (in which production and efficiency are not the primary concern), would not be suitable for scale-up production plants. For completeness, the observations are included, even though not part of the study scope, and are given in Section 5 of this report.

4.4 The Second Evaluation Approach:

The approach used for the second evaluation of any instrument device was primarily a subjective one, and relied on engineering judgment about the potential problems involved in scale-up applications. Unusual problems arising from combinations of process requirements were found. For example, the requirement for flow measurement of an abrasive gas (vapor)-particulate mixture (as in the $CO_2$ Acceptor Plant) is discussed in paragraph 6.1.3.

4.5 Second Evaluation Results:

The results of this second evaluation are given in Section 6 of this report and are categorized by plant, and by physical parameter (measurement).

In several cases, instrument problems for the existing plant were found to be irrelevant for scale-up plants because the instrumentation related to process development efforts rather than to research needs. For example, we learned that many of the devices used on electric heating elements in the pilot plant were there to solve operational problems (coking, etc.) on the heaters. See paragraph 6.1.2.

It can be anticipated t[illegible] stringent operational requirements for a scale-up application may give rise to instrument applications not of concern on pilot plants. For example, the large quantities of potentially hazardous materials will require numerous devices to automatically initiate protection systems upon detection of significant process deviations. These deviations may occur as a result of equipment failures, operator error, or external events.

The primary areas of concern which may require further research and development effort are felt to be:

4.5.1 Responsiveness to changing safety codes in fired vessels and furnaces.

4.5.2 Response to changing environmental requirements. These points are not further addressed in this report.

4.6 Suggestions for devices that may be used in scaled-up plants:

The following list of manufacturer's data sheets provide data on some current "State-of-the-art" instruments that in our judgment may be scaled-up. To actually review and suggest specific applications for each of the suggested instruments would take much more time than the present study permits.

4.6.1 Manufacturer's Data Sheets

| | |
|---|---|
| Alloy Engineering Co., Inc. | Thermowells |
| Amiprodux | Level Instrument |
| Arcas Division Anacon | Process Chromatograph |
| Barton ITT | Sulphur Titrator |
| Barton ITT | Density Gauge, Mass Flow |
| Barton ITT | Flowmeters |
| BLH | Strain Gauge Transducers |
| Concept Engineering | Non-Contact Temperature |
| Controlotron Corp. | Clampitron Flowmeter |
| Sigma | Fuel Gas Colorimeter |
| Environmental Products | Stack & Atmosphere Monitors |
| Extranuclear Laboratories, Inc. | Mass Spectrometer |
| Flow Technology | Flow/No Flow Switch |
| HYDE | Oil/Water Separators |
| I. C. Transducers, Inc. | Piezoresistive Transducers |
| Ircon | Non-Contact Temperature Measurement System |
| Ion Track Instruments, Inc. | Trace Gas Chromatograph |
| Kay Ray, Inc. | Level Monitors |
| Kistler | Piezoresistive Transducers |
| Lebow | Load Cells |
| Nusonics | Sound Velocity Density Measurement |
| Solatron/Solartron | Density by Sound |
| Standard Controls, Inc. | Bonded Strain Gauge Pressure Transducers |
| Teledyne | Gas Analyzers |
| Transducers, Inc. | Bonded Strain Gauge Pressure Transducers |
| Viatran | Strain Gauge Transducers |
| Wahl | I. R. Thermometers |
| Wesmar | Ultra Sonic Level and Flow |

4.6.1 Data not included, but recommended:

Schaevitz Handbook of Measurement and Control.
Available from: Torkelson Associates (312) 446-9085

The Bell and Howell Pressure Transducer Handbook.
Available from: CEC Division (312) 298-2450

Envirometrics
Specializing in: $No_2$, $NO_x$, CO, $SO_2$, $H_2S$ Emissions

13311 Beach Avenue
Marina Del Ray, Calif. 90291

(213) 821-4918

Multi-Gas Mass Spectrometer

Perkin-Elmer Corp.
Industrial Instruments Division
Pomona, Calif.

Local Rep. may be called at 495-3700

4.7 Development Required:

There will be development, or improvement of existing instruments required. In Sections 6.1 thru 6.5 below, analysis of our second evaluation suggests approaches; but realization of the physical size of projected coal conversion process vessels mandates that a completely different approach should be considered as an alternative.

Our review has spotlighted two (2) problem areas which are fully documented in Sections 6.1 thru 6.5. They are:

A. Fluidized Bed Level Detection and Measurement.
B. Oil/Water/Tar Interface Detection and Measurement.

## 5. SUMMARY OF OVERVIEW OF PROCESS APPLICATIONS

5.1 The coal conversion processes examined provide examples of a number of conditions which make for problems in Instrument and Control Applications. They are:

5.1.1 Gas/liquid slurry transport. Basically the fine ash, coal, dolomite, and lignite are abrasive. No matter what the transport medium is, gauge tap plugging is a certainty, in the long run. Coal crushing and grinding areas are hazardous, from a spark or ignition viewpoint.

5.1.2 Fluidized beds have physical properties that make for measurement problems. Differential pressures across the bed will seldom prove anything but erratic, since the density of the fluid bed will vary with time. Moreover, devices to "look down" at the fluidized bed surface will find interference from coal dust or lignite dust and/or coal gas vapors, which distorts readings. Some means of volumetric averaging (perhaps by using many more individual measurement) seems required.

5.1.3 Coal conversion process products, oils, tars, etc., generally are fairly dirty (i.e., laden with suspended solids). Decanters and separators are used to separate output product from condensate and quench fluids. The suspended matter interferes with detection of the oil or tar/water interface. Normal oil processing densitometers or capacitance interface detectors may have to be improved to provide separation action.

5.2 This table summarizes areas in which operations personnel have expressed concern about the suitability of the installed instrumentation:

| | COED | $CO_2$ Acceptor | SRC | Synthane | HYGAS |
|---|---|---|---|---|---|
| Solids/Mass Flow Rate | X | X | X | | X |
| % Solids in Slurry - (Density) | X | X | X | X | X |
| Oil - Water Interface | X | | | | |
| Bed Heights | X | | | X | |
| Bed Density | X | | | X | |
| $H_2$ Flow Rate | X | | | | |
| $O_2$ Analyzer | X | | | | |
| $SO_2$ Stack Gas | X | | | | |
| $H_2S$/COS | X | | | | |
| C/Ash Ratio | | | | | X |
| Sampling Technique | | | X | | X |
| Chromatograph Improvement | | X | | | |
| Fe/$H_2$/Steam | | | | | X |
| Slurry Melting Point | | | X | | |
| D/P Interpretation | | X | | | |
| Char/Acceptor Proportion | | X | | | |
| Thermowell Failure | | | | X | |

## 6. DETAILED DISCUSSION OF SECOND EVALUATION RESULTS

This section discusses the computer listings of the five sets of instruments on which second evaluations were made. These are broken down by plant sets as follows:

6.1 COED

6.2 $CO_2$ Acceptor

6.3 Synthane

6.4 SRC

6.5 HYGAS

### 6.1 COED.

Instruments Reviewed and Comments.

6.1.1 ANALYZERS, Pyrolysis and Recycle Gas.

Recommend standards for sample conditioning and instrument sensitivity.

6.1.2 FLOW to and Control of Electric Heaters.

The problem with electric heaters is dropped from further review. Other heat transfer methods would be used for large scale plants.

6.1.3 FLOW TRANSMITTERS.

Pyrolyzers Fines, Recycle Gas, Pyrolysis Gas, External Cyclone Fines Flow, Raw Coal Flow. Flow ideally should be reported in mass flow units (which would relate well to plant materials balance). Measurement techniques which should be considered are: nuclear gaging for density, sonic up and down stream velocity measurement, sonic leading edge flowmeters which may be clamped on to the pipe (or which provide a low (or nil) profile) for abrasion resistance to the process media. In the COED Plant, fairly long lines are utilized as a flow metering device by using differential pressure transmitters. The D/P instrument lines are purged, hence the accuracy of the measurement is therefore questioned. The purge line pressures must be identical on both sides of the D/P transmitter or the measurement will prove erratic.

6.1.4.A LEVELS.

Oil Storage, Oil/Water Decanter, these levels by D/P transmitters are standard techniques. In the decanter, however, since the oil is dirty, a combination of level and density is required.

6.1.4.B Precoat Filter Oil Level Transmitter.

Oil Levels on both the Slurry Oil (Filtrate) Tank and the Precoat Mix Oil are necessary.

6.1.4.C Pyrolyzer Fluid Bed Level.

This measurement is currently approximated using several sets of overlapping pressure transmitters. Because of the extensive purging required, a direct measurement is preferable. If average bed density is pertinent, use a D/P. Compare D/P to difference (measured) between taps and observed height.

6.1.5 WEIGH HOPPERS.

In a large scale plant weigh hoppers for solid material batching will probably give way to weigh belts.

6.1.6 ANALYSIS, Acid Gas Components.

While not shown on flow sheets, measurement of $H_2S$ and COS will be required in a full scale plant. $H_2S$ and COS will exist in fairly large amounts in phase I gasification. After purification, analyzers sensitive to minute quantities of $H_2S$ and COS are required. Records of total sulphur must be filed to satisfy Federal and State examiners. Flue gases and stack gas must be monitored and controlled to EPA requirements. Current "State-of-the-Art" systems should be studied and improved as required.

6.2 $CO_2$ ACCEPTOR Instruments Reviewed and Comments.

6.2.1 ANALYTICAL Chromatograph.

In this case observe the application. Check sample conditioning. Relate columns to constituents to be measured.

6.2.2.A DIFFERENTIAL PRESSURE TRANSMITTERS related to Lignite Preheater, Gasifier and Devolitilyzer Bed Heights. A direct "look-see" at bed heights is preferred.

6.2.2.B DIFFERENTIAL PRESSURE TRANSMITTERS Related to Charlift Line.

The application is related to flow or hang up. Either way clamp on sonics or ultrasonics would be better. A solid state flow switch could detect a flow/no flow state. Any device in the direct flow path must be designed to process design conditions and to withstand abrasion.

6.2.3 PURGE FLOW INDICATORS.

Instrumentation applications should be designed to minimize purge flow.

6.2.4 FLOW TRANSMITTERS AND FLOW INDICATING CONTROLLERS.

Flow control without linearization should be discouraged. It only works if the normal flow rate occurs near centerscale and with at least 10% of full scale flow rate of the indicator. Deviations will require frequent controller adjustment.

6.2.5 QUENCH WATER/OIL INTERFACE.

This measurement is troublesome because the oil water specific gravities are close. Other sensing such as dielectric constant or conductivity or even viscosity may be combined with gravimetric methods to improve this problem measurement.

6.2.6 DOLOMITE/LIGNITE BIN LEVEL SWITCHES.

This measurement is similar to fly-ash bin measurement in fossil fuel plants. However, since this is part of the process, it should be a level measurement signal to a high or low signal level switch.

6.2.7 WEIGHT TRANSMITTERS.

Weight transmitters will probably play a different role in major plants. In the $CO_2$ Acceptor the application must be critically evaluated so that material balances can be easily related to mass flows.

6.2.8 GENERAL.

In general, the application of instruments to the process seemed to be well defined, except in purge flow and pressure devices. Separate purge flow sheets would aid the plant operator to expedite maintenance.

6.3 SRC (Solvent Refined Coal) Instruments Reviewed and Comments.

6.3.1 ANALYZERS.

Analyzers were not shown on Flow Sheets but future plants should have a rapid analyzer to show carbon, ash, and sulphur content.

6.3.2 GENERAL.

Flow Sheets lacked legibility, but as is the case with all slurries, flow and pressure measurement problems exist. Oil/water interface problems also exist. These should be solved before instrumentation for a major SRC plant is selected. Here again, mass flow, appears to be the term required. Weight feeders must be carefully designed.

6.4 SYNTHANE Instruments Reviewed and Comments.

6.4.1 ANALYTICAL INSTRUMENTS.

Analytical instruments as shown on the flow sheets seem erratically placed and not clearly defined. On a full scale Synthane plant such analyzers must be specified to fit process design conditions and carefully located. Gas under analysis should be conditioned as described by recommended standards for sampling conditioning (Section 5.2.2). $H_2S$, COS must be analyzed and records kept for regulatory agencies.

6.4.2 FLOW CONTROL.

Flow control major scale up problem will be the right device with a linearized signal to control a flow control valve. Rotometers, as a signal transmitter for flow control will not scale-up.

6.4.3 CHAR HOPPER LEVEL.

Char hopper level appears to be a problem. Check device used. Fossil fuel plant fly ash level may be a similar case, it is felt that nuclear gauging might be more reliable on scaled-up plants.

6.4.3.A SLURRY TANK LEVEL.

Surry tank level, a new or improved device will probably be required. Density of slurry is not, at this time, predictable. Plugging differential lines are a continuing problem.

6.4.3.B GASIFIER/PREHEATER BED LEVELS.

Gasifier/preheater bed levels are problematical. Heat and pressure render the measurement difficult. Plugging instrument lines render differential pressure signals erratic. Unpredictable slurry densities will yield unpredictable level indication or control. Recommend a new look for a more practical way to this measurement.

6.4.4 DECANTER LEVEL.

Contaminated oils and water render normal level gauging totally inadequate. A better way must be found to measure Oil/water interface. (See paragraph 6.2.5).

6.4.5 TEMPERATURE WELLS.

Temperature wells are not shown on the flow sheets, but on any lines bearing a coal or ash slurry, the wells must be properly specified. Specify: Machined Bar Stock Thermowells of an alloy designed to withstand erosion. Welded or built up wells should not be accepted, because of erosion.

6.5 HYGAS Instruments Reviewed and Comments.

6.5.1 ANALYZERS.

The gases mentioned are CO, $CO_2$, $H_2$, and Quench Gas. $H_2S$, COS Analyzers are not shown and should be shown because of State requirements, moreover a Btu recorder is not shown. A scanning valve is used to switch analysis streams. Do they have a problem?

6.5.2 FLUIDIZED BED LEVEL.

The Hygas Reactor Internals are very complex and presents a very real instrumentation design problem. Devices designed to measure open pot bed levels may not work in the Hygas reactor. We recommend that a conference should be set up with IGT to analyze the process design conditions in the various sections of the reactor. Instrumentation can then be fitted to the process. Once systems are tested, recommendations for scaled-up plants will be in order.

6.5.3 VENTURI, SLURRY FLOW.

Venturi, slurry flow request a critical assessment of flow problems. Apply devices recommended and improved for mass flow.

6.5.4 QUENCH SEPARATOR LEVEL.

Only level devices are shown here. Will a scaled-up plant require a decanter?

6.5.5 CYCLONE DIPLEG FLOW.

Question if flow rate is required or is this an indication of a hang-up. In other words, what is the process design requirement?

6.5.6 SLURRY DENSITY.

What has IGT tried? Ask what improvements are required.

6.5.7 FEED BLOWDOWN DRUM LEVEL.

Will decanter be required on scale-up? Develop oil/water interface sensors to fit the process.

6.5.8 REMARKS.

The Hygas Process shows complexities that do not appear in other processes, probably because of the age of the process and the level of documentation achieved.

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AI 001 | 113-1 | INSTRUMENT AIR DRYER BED 1 MOISTURE INDICATOR |
| AI 002 | 113-1 | INSTRUMENT AIR DRYER BED 2 MOISTURE INDICATOR |
| AM 001 | 111-3 | ROLLER MILL MOTOR AMMETER |
| AM 002 | 111-3 | MAIN AIR CIRCULATING FAN AMMETER |
| AN 119 | 111-2 | COAL SILO LEVEL HI ALARM |
| AN 131 | 111-3 | VELOCITY SEPARATOR TEMPERATURE HI ALARM |
| AN 150-H | 111-3 | PULVERIZED COAL STORAGE TANK LEVEL HI ALARM |
| AN 150-L | 111-3 | PULVERIZED COAL STORAGE TANK LEVEL LO ALARM |
| AN 204 | 111-4 | FIRST STAGE RECYCLE GAS COMPRESSOR DSCH PRESS ANNUNC |
| AN 216 | 111-4 | FIRST STAGE RECYCLE GAS COMP SUCTION HDR PRESS LO ANNUNC |
| AN 218 | 111-5 | FIRST STAGE OIL DEHYDRATOR LEVEL ANNUNCIATOR |
| AN 228 | 111-5 | FIRST STAGE OIL WEIGH SCALE WEIGHT HI ANNUNCIATOR |
| AN 229 | 111-5 | FIRST STAGE OIL WEIGH SCALE WEIGHT HI-HI ANNUNCIATOR |
| AN 240 | 111-7 | FOURTH STAGE PYROLYZER OXYGEN INLET HI PRESS ANNUNCIATOR |
| AN 302 | 111-6 | FINES WEIGH TANK OVERWEIGHT ANNUNCIATOR |
| AN 303 | 111-6 | FINES WEIGH TANK OVERWEIGHT ANNUNCIATOR |
| AN 319 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR SUCT PRESS LO ANNUNC |
| AN 321 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DSCH PRESS LO ANNUNC |
| AN 362 | 111-9 | PRODUCT OIL HI/LO WEIGHT ANNUNCIATOR |
| AN 393 | 111-10 | FILTER FEED WEIGH TANK HI/LO LEVEL ANNUNCIATOR |
| AN 409 A | 112-1 | OIL FEED TANK A HI/LO ANNUNCIATOR |
| AN 409 B | 112-1 | OIL FEED TANK B HI/LO ANNUNCIATOR |
| AN 419 | 112-1 | PREHEATER COED OIL TUBE WALL TEMPERATURE HI ANNUNCIATOR |
| AN 436 | 112-3 | ENTRAINMENT SEPARATOR DRIP POT HIGH LEVEL ANNUNCIATOR |
| AN 437 | 112-3 | HYDROGEN RECYCLE COMPRESSOR DISCHARGE HI TEMPERATURE ANNUNC |
| AN 438 | 112-3 | RECYCLE GAS LO HYDROGEN ANNUNCIATOR |
| AN 446 | 112-3 | HEAVY OIL PRODUCT WEIGH TANK A OVERWEIGHT ANNUNCIATOR |
| AN 447 | 112-3 | HEAVY OIL PRODUCT WEIGH TANK B OVERWEIGHT ANNUNCIATOR |
| AN 610 | 113-1 | INSTRUMENT AIR HEADER NITROGEN INLET FLOW ANNUNCIATOR |
| AN 630L | 113-1 | COOLING TOWER PUMPS DISCHARGE HEADER PRESSURE LOW ANNUNC |
| AR 002C | 112-3 | RECYCLE GAS ANALYTICAL RECORDER CONTROL |
| AR 002R | 112-3 | RECYCLE GAS ANALYTICAL RECORDER |
| FA 610 | 113-1 | INSTRUMENT AIR SYSTEM NITROGEN INLET FLOW ALARM |
| FE 610 | 113-1 | INSTRUMENT AIR SYSTEM NITROGEN INLET FLOW ELEMENT |
| FG 014 | 112-3 | HYDROGEN RECYCLE COMPRESSOR COOLING WATER RETURN FLOW GLASS |
| FG 015 | 112-3 | HYDROGEN RECYCLE COMPRESSOR AFTERCOOLER CLG WTR RTN FLOW IND |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FI 001 | 111-6 | EXTERNAL CYCLONE DSCH NITROGEN FLOW INDICATOR |
| FI 002 | 111-7 | MIXING TEE 11 NITROGEN INLET FLOW INDICATOR |
| FI 003 | 111-7 | CHAR CONVEYOR NITROGEN INLET FLOW INDICATOR |
| FI 004 | 111-10 | FILTRATE RECEIVERS VENT HEADER FLOW INDICATOR |
| FI 009 | 112-3 | HYDROGEN RECYCLE COMPRESSOR SUCTION FLOW INDICATOR |
| FI 010 | 112-1 | PLANT AIR FLOW INDICATOR |
| FI 011 | 112-1 | MAIN STEAM FLOW INDICATOR |
| FI 012 | 112-1 | NITROGEN FLOW INDICATOR |
| FI 020 | 113-1 | INSTRUMENT AIR DRYER REGENERATION AIR FLOW INDICATOR |
| FIC 151 | 111-4 | RECYCLE GAS TO MIXING TEE #1 FLOW CONTROLLER |
| FIC 201 | 111-4 | RECYCLE GAS TO FLUIDIZING GAS HEATER FLOW CONTROLLER |
| FIC 205 | 111-4 | 10 KW RECYCLE GAS HEATER INLET FLOW CONTROLLER |
| FIC 208 | 111-5 | SCRUB LIQUOR TO VENTURI SCRUBBER COOLER FLOW INDICATING CONT |
| FIC 214 | 111-5 | SCRUB LIQUOR TO GAS LIQUID SEPARATOR FLOW INDICATING CONT |
| FIC 219 | 111-4 | 1.5 KW RECYCLE GAS HEATER INLET FLOW CONTROLLER |
| FIC 225 | 111-6 | 30 KW RECYCLE GAS HEATER INLET INDICATING FLOW CONTROL |
| FIC 235 | 111-6 | 30 KW RECYCLE GAS HEATER INLET INDICATING FLOW CONTROLLER |
| FIC 236 | 111-6 | 30 KW RECYCLE GAS HEATER INLET INDICATING FLOW CONTROLLER |
| FIC 243 | 111-7 | 25 KW OXYGEN HEATER NITROGEN INLET FLOW IND CONTROL |
| FIC 245 | 111-7 | 10 KW RECYCLE GAS HEATER INLET FLOW IND CONTROL |
| FIC 246 | 111-7 | 25 KW OXYGEN HEATER INLET IND FLOW CONTROL |
| FIC 248 | 111-7 | 30 KW RECYCLE GAS HEATER INLET FLOW IND CONTROL |
| FIC 310 | 111-8 | VENTURI SCRUBBER SCRUB LIQUOR INLET FLOW IND. CONTROLLER |
| FIC 311 | 111-8 | GAS/LIQUID SEPARATOR SCRUB LIQUOR INLET FLOW IND. CONTROLLER |
| FIC 315 | 111-8 | VENTURI DEMISTER SCRUB LIQUOR INLET FLOW IND CONTROLLER |
| FIC 419 | 112-3 | RECYCLE HYDROGEN INDICATING FLOW CONTROL |
| FIC 420 | 112-2 | HYDRO TREATING REACTOR B INLET OIL INDICATING FLOW CONT |
| FIC 421 | 112-2 | HYDRO TREATING REACTOR B COED OIL INLET IND FLOW CONT |
| FIC 468 | 112-2 | HIGH PRESSURE WATER PUMP DISCHARGE FLOW INDICATOR CONTROLLER |
| FIC 468V | 112-3 | WATER BREAK TANK HIGH PRESS WTR INLET FLOW CONTROL VALVE |
| FR 001 | 111-5 | PYROLYSIS GAS TO INCINERATOR FLOW RECORDER - 2 CHART |
| FR 002 | 111-4 | RECYCLE GAS TO #1 MIXING TEE FLOW RECORDER 2 CHART |
| FR 003 | 111-4 | FIRST STAGE PYROLYZER COAL FLOW RECORDER - 3 CHARTS |
| FR 004 | 111-4 | 10 KW RECYCLE GAS HEATER INLET FLOW RECORDER |
| FR 005 | 111-6 | SECOND/THIRD MIXED COAL INLET FLOW RECORDER - 2 CHARTS |
| FR 006 | 111-6 | 30 KW RECYCLE GAS HEATERS INLET FLOW RECORDER - 3 CHART |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FR 007 | 111-7 | FOURTH STAGE PYROLYZER PYROLYSIS GAS FLOW RCDR -DUAL CHART |
| FR 008 | 111-7 | 10 KW/30 KW RECYCLE GAS HEATER INLET FLOW RECORDER DUAL CHT |
| FR 009 | 111-7 | 25 KW OXYGEN HEATER INLET FLOW RECORDER - DUAL CHART |
| FR 021 | 112-3 | MAKE-UP HYDROGEN COMPRESSOR DISCHARGE FLOW RECORDER |
| FR 419 | 112-3 | RECYCLE GAS FLOW RECORDER |
| FR 420 | 112-3 | MEDIUM PRESSURE COED OIL FLOW RECORDER |
| FR 421 | 112-3 | HYDRO TREATING REACTOR B COED OIL INLET FLOW RECORDER |
| FRC 247 | 111-7 | 35 KW STEAM SUPERHEATER INLET FLOW RECORDING CONTROL |
| FRC 249 | 111-6 | THIRD STAGE PYROLYZER OXYGEN INLET FLOW RECORDING CONTROLLER |
| FRC 437 | 112-3 | PURGE & VENT GAS RECORDING FLOW CONTROL - DUAL CHART |
| FT 151 | 111-4 | RECYCLE GAS TO MIXING TEE #1 FLOW TRANSMITTER |
| FT 201 | 111-4 | RECYCLE GAS TO FLUIDIZING GAS HEATER FLOW TRANSMITTER |
| FT 205 | 111-4 | 10 KW RECYCLE GAS HEATER INLET FLOW TRANSMITTER |
| FT 219 | 111-4 | 1.5 KW RECYCLE GAS HEATER INLET FLOW TRANSMITTER |
| FT 243 | 111-7 | 25 KW OXYGEN HEATER NITROGEN INLET FLOW TRANSMITTER |
| FT 246 | 111-7 | 25 KW OXYGEN HEATER INLET FLOW TRANSMITTER |
| FT 247 | 111-7 | 35 KW STEAM SUPERHEATER INLET FLOW TRANSMITTER |
| FT 249 | 111-6 | THIRD STAGE PYROLYZER OXYGEN INLET FLOW TRANSMITTER |
| FT 420 | 112-2 | HYDRO TREATING REACTOR B INLET OIL FLOW TRANSMITTER |
| FT 421 | 112-2 | HYDRO TREATING REACTOR B COED OIL INLET FLOW TRANSMITTER |
| FT 468 | 112-2 | HIGH PRESSURE WATER PUMP DISCHARGE FLOW TRANSMITTER |
| FTI 001 | 111-5 | PYROLYSIS GAS TO INCINERATOR FLOW TOTALIZER INDICATOR |
| FTI 002 | 111-8 | SECOND STAGE GAS COMPRESSOR SUCTION TOTAL FLOW INDICATOR |
| FTI 003 | 111-5 | OIL/WATER DECANTER CITY WATER FLOW TOTALIZER INDICATOR |
| FTI 004 | 111-5 | SCRUB LIQUOR DISCHARGE FLOW TOTALIZER INDICATOR |
| FTI 005 | 111-9 | OIL/WATER DECANTER WATER INLET FLOW TOTALIZER |
| FTI 006 | 111-9 | SCRUB LIQUOR PURGE DISCHARGE FLOW TOTALIZER INDICATOR |
| FTI 007 | 112-3 | WATER BREAK TANK CITY WATER INLET FLOW TOTALIZER INDICATOR |
| HIC 410B | 112-1 | OIL FEED PUMP B STROKE HAND INDICATING CONTROLLER |
| HIC 410A | 112-1 | OIL FEED PUMP A STROKE HAND INDICATING CONTROLLER |
| LA 119 | 111-2 | COAL SILO LEVEL HI ALARM |
| LA 150-H | 111-3 | PULVERIZED COAL STORAGE TANK LEVEL HI ALARM |
| LA 150-L | 111-3 | PULVERIZED COAL STORAGE TANK LEVEL LO ALARM |
| LA 218 | 111-5 | FIRST STAGE OIL DEHYDRATOR LEVEL ALARM |
| LA 436 | 112-3 | ENTRAINMENT SEPARATOR DRIP POT LEVEL ALARM |
| LC 003 | 113-1 | CHEMICAL TREATMENT TANK LEVEL CONTROL |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LC 423 | 112-2 | HI TEMP FLASH DRUM VAPOR OUTLET LEVEL CONTROLLER |
| LC 431 | 112-2 | LO TEMP FLASH DRUM LEVEL CONTROLLER |
| LC 467 | 112-3 | WATER BREAK TANK LEVEL CONTROLLER |
| LC 655 | 113-1 | CONDENSATE RETURN UNIT LEVEL CONTROLLER |
| LG 005 | 111-10 | COED OIL DAY TANK LEVEL GLASS |
| LG 006 | 113-1 | CONDENSATE RETURN UNIT LEVEL GLASS |
| LG 010 | 112-1 | OIL MEASURING TANK LEVEL GLASS |
| LG 011 | 112-2 | LIGHT OIL WEIGH TANK LEVEL GLASS |
| LG 012 | 112-3 | HEAVY OIL PRODUCT WEIGH TANK LEVEL GLASS |
| LG 013 | 112-3 | HEAVY OIL PRODUCT WEIGH TANK B LEVEL GLASS |
| LG 014 | 112-3 | WASTE WATER TANK LEVEL GLASS |
| LG 015 | 112-3 | WATER BREAK TANK LEVEL GLASS |
| LI 218 | 111-5 | FIRST STAGE OIL DEHYDRATOR LEVEL INDICATOR |
| LI 360 | 111-9 | OIL STORAGE TANK A LEVEL INDICATOR |
| LI 361 | 111-9 | OIL STORAGE TANK B LEVEL INDICATOR |
| LI 388 | 111-10 | FILTER FEED TANK LEVEL INDICATOR |
| LI 460 | 112-4 | OIL STORAGE TANK A LEVEL INDICATOR |
| LI 461 | 112-4 | OIL STORAGE TANK B LEVEL INDICATOR |
| LI 462 | 112-4 | OIL STORAGE TANK C LEVEL INDICATOR |
| LIC 282 | 111-10 | FILTRATE RECEIVER LEVEL INDICATOR CONTROLLER |
| LIC 330 | 111-9 | OIL/WATER DECANTER HEAVY OIL LEVEL INDICATING CONTROLLER |
| LIC 331 | 111-9 | OIL/WATER DECANTER LIGHT OIL LEVEL INDICATING CONTROLLER |
| LIC 340 | 111-9 | HEAVY OIL DEHYDRATOR LEVEL INDICATING CONTROLLER |
| LIC 350 | 111-9 | OIL DEHYDRATOR LEVEL INDICATING CONTROLLER |
| LIC 383 | 111-10 | FILTRATE RECEIVER LEVEL INDICATOR CONTROLLER |
| LIC 422 | 112-2 | HI TEMP FLASH DRUM LEVEL INDICATING CONTROLLER |
| LIC 430 | 112-2 | LO TEMP FLASH DRUM LEVEL INDICATING CONTROLLER |
| LRC 210 | 111-4 | FIRST STAGE PYROLYZER FLUID BED HI LVL RECORDING CONT |
| LRC 220 | 111-6 | SECOND STAGE PYROLYZER FLUID BED MID LVL REC LVL CONT |
| LRC 230 | 111-6 | THIRD STAGE PYROLYZER FLUID BED HI LVL RECORDING LVL CONT |
| LRC 240 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED RECORDING LEVEL CONTROL |
| LT 218 | 111-5 | FIRST STAGE OIL DEHYDRATOR LEVEL TRANSMITTER |
| LT 422 | 112-2 | HI TEMP FLASH DRUM LEVEL TRANSMITTER |
| LT 430 | 112-2 | LO TEMP FLASH DRUM LEVEL TRANSMITTER |
| LT 460 | 112-4 | OIL STORAGE TANK A LEVEL TRANSMITTER |
| LT 461 | 112-4 | OIL STORAGE TANK B LEVEL TRANSMITTER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LT 462 | 112-4 | OIL STORAGE TANK C LEVEL TRANSMITTER |
| P 001 | 111-2 | AREA DUST COLLECTOR PRESSURE |
| P 002 | 111-2 | AREA DUST COLLECTOR SUPPLY DUCT PRESSURE |
| P 003 | 111-3 | CYCLONE COLLECTOR INLET DIFFERENTIAL PURGE |
| P 004 | 111-3 | CYCLONE COLLECTOR INLET DIFFERENTIAL PURGE |
| P 005 | 111-3 | DUST COLLECTOR INLET DIFFERENTIAL PURGE |
| P 006 | 111-3 | DUST COLLECTOR TOP DIFFERENTIAL PURGE |
| P 007 | 111-3 | ROTARY DISCHARGE VALVE SEAL PURGE |
| P 010 | 111-4 | FIRST STAGE PYROLYZER COAL FLOW LOOP US PURGE |
| P 011 | 111-4 | FIRST STAGE PYROLYZER COAL FLOW LOOP DS PURGE |
| P 012 | 111-4 | FIRST STAGE PYROLYZER FLUID BED LO LVL TAP PURGE |
| P 013 | 111-4 | FIRST STAGE PYROLYZER FLUID BED LO LVL TAP PURGE |
| P 014 | 111-4 | FIRST STAGE PYROLYZER FLUID BED MID LVL TAP PURGE |
| P 015 | 111-4 | FIRST STAGE PYROLYZER FLUID BED HI LEVEL TAP PURGE |
| P 016 | 111-4 | FIRST STAGE PYROLYZER CYCLONE B PURGE |
| P 017 | 111-4 | FIRST STAGE PYROLYZER CYCLONE A PURGE |
| P 018 | 111-4 | FIRST STAGE PYROLYZER DSCH VALVE PURGE |
| P 019 | 111-4 | FIRST STAGE PYROLYZER DSCH VALVE CAVITY PURGE |
| P 020 | 111-4 | FIRST STAGE PYROLIZER DSCH VALVE CAVITY PURGE |
| P 021 | 111-4 | FIRST STAGE PYROLYZER DSCH VALVE CAVITY PURGE |
| P 023 | 111-6 | SECOND STAGE PYROLYZER COAL FLOW TAP LINE PURGE |
| P 024 | 111-4 | EXTERNAL CYCLONE FINES DUCT PURGE |
| P 025 | 111-4 | EXTERNAL CYCLONE FINES DUCT PURGE |
| P 026 | 111-4 | FINES FEEDER ROTARY VALVE SEAL PURGE |
| P 027 | 111-6 | SECOND STAGE PYROLYZER FINES FLOW TAP LINE PURGE |
| P 028 | 111-6 | SECOND STAGE PYROLYZER FINES FLOW TAP LINE PURGE |
| P 029 | 111-4 | FIRST STAGE PYROLYZER PURGE |
| P 030 | 111-4 | VENTURI COOLER LINE PURGE |
| P 031 | 111-5 | PYROLYSIS GAS D/P LINE PURGE |
| P 032 | 111-5 | RECYCLE GAS D/P LINE PURGE |
| P 033 | 111-5 | RECYCLE GAS D/P LINE PURGE |
| P 034 | 111-4 | FIRST STAGE RECYCLE GAS COMP A SEAL PRESS IND |
| P 035 | 111-4 | FIRST STAGE RECYCLE GAS COMP B SEAL PRESS IND |
| P 040 | 111-6 | SECOND STAGE PYROLYZER FLUID BED GRATE LVL TAP LINE PURGE |
| P 041 | 111-6 | SECOND STAGE PYROLYZER GRATE LEVEL TAP PURGE |
| P 042 | 111-6 | SECOND STAGE PYROLYZER FLUID BED LO LVL TAP PURGE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| P 043 | 111-6 | SECOND STAGE PYROLYZER FLUID BED MID LVL TAP PURGE |
| P 044 | 111-6 | SECOND STAGE PYROLYZER CYCLONE B LVL TAP LINE PURGE |
| P 045 | 111-6 | SECOND STAGE PYROLYZER CYCLONE A LVL D/P TAP LINE PURGE |
| P 046 | 111-6 | SECOND STAGE PYROLYZER CHAR OUTLET CONT VLV SEAL PURGE |
| P 047 | 111-6 | SECOND STAGE PYROLYZER CHAR OUTL CONT VLV BODY CAVITY PURGE |
| P 048 | 111-6 | SECOND STAGE PYROLYZER CHAR OUTL CONT VLV BODY CAVITY PURGE |
| P 049 | 111-6 | SECOND STAGE PYROLYZER CHAR OUTL CONT VLV BODY CAVITY PURGE |
| P 050 | 111-6 | THIRD STAGE PYROLYZER CHAR INLT FLOW TAP LINE PURGE |
| P 051 | 111-6 | THIRD STAGE PYROLYZER CHAR INLET FLOW TAP LINE PURGE |
| P 052 | 111-6 | THIRD STAGE PYROLYZER CHAR DSCH VLV SEAL PURGE |
| P 053 | 111-6 | THIRD STAGE PYROLYZER CHAR DSCH VLV BODY CAVITY PURGE |
| P 054 | 111-6 | THIRD STAGE PYROLYZER CHAR DSCH VLV BODY CAVITY PURGE |
| P 055 | 111-6 | THIRD STAGE PYROLYZER CHAR DSCH VLV BODY CAVITY PURGE |
| P 056 | 111-6 | SECOND STAGE PYROLIZER MIXED FUEL COAL TAP LINE PURGE |
| P 057 | 111-6 | SECOND STAGE PYROLYZER MIXED COAL FLOW TAP LINE PURGE |
| P 058 | 111-6 | THIRD STAGE PYROLYZER FLUID BED LO LVL TAP PURGE |
| P 059 | 111-6 | THIRD STAGE PYROLYZER FLUID BED MID LVL TAP PURGE |
| P 060 | 111-6 | THIRD STAGE PYROLYZER FLUID BED TAP LINE PURGE |
| P 061 | 111-6 | THIRD STAGE PYROLYZER FLUID BED HI LVL TAP LINE PURGE |
| P 062 | 111-6 | THIRD STAGE PYROLYZER TOP/DSCH D/P TAP LINE PURGE |
| P 063 | 111-6 | THIRD STAGE PYROLYZER DSCH TAP LINE PURGE |
| P 064 | 111-6 | THIRD STAGE PYROLIZER OVERFLOW DSCH VLV SEAL PURGE |
| P 065 | 111-6 | THIRD STAGE PYROLYZER OVERFLOW DSCH VLV BODY CAVITY PURGE |
| P 066 | 111-6 | THIRD STAGE PYROLYZER OVERFLOW DSCH VLV BODY CAVITY PURGE |
| P 067 | 111-6 | THIRD STAGE PYROLYZER OVERFLOW DSCH VLV BODY CAVITY PURGE |
| P 068 | 111-7 | 11 MIXING TEE NITROGEN INLET LINE PURGE |
| P 069 | 111-7 | FOURTH STAGE PYROLYZER PYROLYSIS GAS TAP LINE PURGE |
| P 070 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH CONTROL VLV SEAL PURGE |
| P 071 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH CONT VLV BODY CAVITY PURGE |
| P 072 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH CONT VLV BODY CAVITY PURGE |
| P 072A | 170-4 | NITROGEN SYSTEM PURGE |
| P 073 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH CONT VLV BODY CAVITY PURGE |
| P 074 | 111-6 | THIRD STAGE PYROLYZER COAL/CHAR FLOW TAP LINE PURGE |
| P 075 | 111-6 | THIRD STAGE PYROLYZER COAL/CHAR INLT FLOW TAP LINE PURGE |
| P 076 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED LO LVL TAP LINE PURGE |
| P 077 | 111-7 | FOURTH STAGE PYROLIZER FLUID BED MID LEVEL TAP LINE PURGE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| P 078 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED HI LVL TAP LINE PURGE |
| P 079 | 111-7 | FOURTH STAGE PYROLYZER HI LVL TAP LINE PURGE |
| P 080 | 111-7 | FOURTH STAGE PYROLYZER OUTLET LINE PURGE |
| P 081 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH VALVE SEAL PURGE |
| P 082 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH VALVE BODY CAVITY PURGE |
| P 083 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH VALVE BODY CAVITY PURGE |
| P 084 | 111-7 | FOURTH STAGE PYROLYZER CHAR DSCH VALVE BODY CAVITY PURGE |
| P 085 | 111-7 | CHAR STORAGE DSCH GATE LINE PURGE |
| P 086 | 111-7 | CHAR CONVEYOR PURGE |
| P 090 | 111-6 | EXTERNAL CYCLONE PYROLYSIS GAS INLT FLOW TAP LINE PURGE |
| P 091 | 111-6 | EXTERNAL CYCLONE PYROLYSIS GAS INLT FLOW TAP LINE PURGE |
| P 092 | 111-8 | GAS RECOVERY D/P TAP LINE PURGE |
| P 093 | 111-8 | ELECTROSTATIC PRECIPITATOR PYROLYSIS GAS OUTL TAP LINE PURGE |
| P 094 | 111-8 | PYROLYSIS GAS TAP LINE PURGE |
| P 095 | 111-8 | PYROLYSIS GAS TAP LINE PURGE |
| P 097 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR SHAFT SEAL PURGE |
| P 098 | 111-10 | FILTER FEED TANK LEVEL INDICATOR PURGE |
| PA 204 | 111-4 | FIRST STAGE RECYCLE COMPRESSOR DSCH PRESS ALARM |
| PA 216 | 111-4 | FIRST STAGE GAS COMP SUCTION HDR PRESS ALARM LO |
| PA 220 | 111-6 | SECOND STAGE PYROLYZER CYCLONE B LVL HI PRESS ALARM |
| PA 240 | 111-7 | FOURTH STAGE PYROLYZER OXYGEN INLET PRESSURE ALARM |
| PA 319 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR SUCT PRESS LO ALARM |
| PA 321 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DSCH PRESS LO ALARM |
| PA 630 | 113-1 | COOLING TOWER PUMPS DISCHARGE HEADER PRESSURE ALARM |
| PC 001 | 111-3 | NATURAL GAS TO AIR HEATER LO PRESSURE CONTROL |
| PC 002 | 111-3 | NATURAL GAS TO AIR HEATER HI PRESSSURE CONTROL |
| PC 003 | 111-3 | COMBUSTION AIR TO AIR HEATER LO PRESSURE CONTROL |
| PC 004 | 111-3 | AIR HEATER DISCHARGE PRESSURE CONTROL |
| PC 009 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR OIL PRESSURE CONTROLLER |
| PC 015 | 111-4 | FIRST STAGE RECYCLE GAS COMP A OIL OUTL PRESS CONT LO |
| PC 016 | 111-4 | FIRST STAGE RECYCLE GAS COMP B OIL OUTL PRESS CONT LO |
| PC 024 | 112-1 | COED OIL PREHEATER COMB CONT PRESSURE CONTROL |
| PC 029 | 112-3 | HYDROGEN RECYCLE COMPRESSOR OIL PRESSURE CONTROLLER |
| PC 254 | 112-1 | COED OIL PREHEATER COMB CONT PRESSURE CONTROL |
| PC 256 | 112-1 | COED OIL PREHEATER COMB CONT PRESSURE CONTROL |
| PC 420 | 112-1 | PREHEATER COED OIL INLT/OUTL DIFFL PRESS CONTROLLER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PCV 007 | 111-10 | FILTRATE RECEIVERS VENT HEADER PRESSURE CONTROL VALVE |
| PCV 008 | 113-1 | COOLING TOWER PUMPS RECIRCULATION PRESSURE CONTROL VALVE |
| PCV 010 | 111-7 | OXYGEN HEADER PRESSURE CONTROL VALVE |
| PCV 012 | 113-1 | PLANT AIR PRESSURE CONTROL VALVE |
| PCV 021 | 112-2 | HYDRO TREATING REACTOR B OUTL PRESS CONTROL VALVE |
| PCV 027 | 112-3 | RECYCLE GAS PRESSURE CONTROL VALVE |
| PCV 029 | 112-3 | RECYCLE GAS PRESSURE CONTROL VALVE |
| PCV 034 | 113-1 | INSTRUMENT AIR HEADER NITROGEN INLET PRESSURE CONTROL VALVE |
| PCV 250 | 111-7 | CHAR COOLER COOLING WATER SUPPLY PRESSURE CONTROL VALVE |
| PCV 419 | 112-1 | PREHEATER STEAM INLET PRESSURE CONTROL VALVE |
| PDC 215 | 111-4 | FIRST STAGE PYROLYZER CYCLONE B LVL D/P CONT |
| PDI 135 | 111-3 | CYCLONE COLLECTOR PURGE LINE DIFFERENTIAL |
| PDI 137 | 111-3 | DUST COLLECTOR PURGE LINE DIFFERENTIAL |
| PDI 202 | 111-6 | SECOND STAGE PYROLYZER FINES FLOW D/P INDICATOR |
| PDI 208 | 111-5 | RECYCLE GAS DIFFERENTIAL PRESSURE INDICATOR |
| PDI 209 | 111-5 | PYROLYSIS GAS DIFFERENTIAL PRESSURE INDICATOR |
| PDI 211 | 111-4 | FIRST STAGE PYROLYZER FLUID BED MID LVL D/P INDICATOR |
| PDI 212 | 111-4 | FIRST STAGE PYROLYZER CYCLONE A PURGE DIFFERENTIAL PI |
| PDI 213 | 111-4 | FIRST STAGE PYROLYZER PURGE LINE DIFFERNTIAL PRESS IND |
| PDI 214 | 111-4 | FIRST STAGE PYROLYZER FLUID BED LO LVL D/P INDICATOR |
| PDI 216 | 111-5 | RECYCLE GAS DIFFERENTIAL PRESSURE INDICATOR |
| PDI 221 | 111-6 | SECOND STAGE PYROLIZER FLUID BED LO LVL D/P INDICATOR |
| PDI 223C | 111-6 | EXTERNAL CYCLONE PYROLYSIS GAS INLT FLOW D/P INDICATOR |
| PDI 227 | 111-6 | SECOND STAGE PYROLIZER COAL FLOW D/P INDICATOR |
| PDI 231 | 111-6 | THIRD STAGE PYROLYZER FLUID BED MID LVL D/P INDICATOR |
| PDI 232C | 111-6 | THIRD STAGE PYROLYZER TOP/DSCH D/P INDICATOR |
| PDI 233 | 111-6 | SECOND STAGE PYROLYZER FLUID BED GRATE LVL D/P INDICATOR |
| PDI 235 | 111-6 | SECOND STAGE PYROLYZER MIXED COAL FLOW D/P INDICATOR |
| PDI 236 | 111-7 | FOURTH STAGE PYROLYZER PYROLYSIS GAS DSCH D/P INDICATOR |
| PDI 237 | 111-6 | THIRD STAGE PYROLYZER CHAR INLET FLOW D/P INDICATOR |
| PDI 241 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED MID LVL D/P INDICATOR |
| PDI 242 | 111-7 | FOURTH STAGE PYROLYZER HI LVL DIFFERENTIAL PRESS INDICATOR |
| PDI 243 | 111-6 | THIRD STAGE PYROLYZER FLUID BED LO LVL DIFF PRESS INDICATOR |
| PDI 245 | 111-6 | THIRD STAGE PYROLYZER COAL/CHAR INLT FLOW D/P INDICATOR |
| PDI 249 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED LO LVL D/P INDICATOR |
| PDI 271 | 111-2 | AREA DUST COLLECTOR DUCT PURGE LINE DIFFERENTIAL |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PDI 272 | 111-6 | SECOND STAGE PYROLYZER CYCLONE B LVL TAP LINE PURGE |
| PDI 317 | 111-8 | GAS RECOVERY PRESSURE DIFFERENTIAL INDICATOR |
| PDI 318 | 111-8 | PYROLYSIS GAS DIFFERENTIAL PRESSURE TRANSMITTER |
| PDI 319 | 111-8 | GAS/WATER SEPARATOR PYROLYSIS GAS LINE D/P INDICATOR |
| PDT 418 | 112-1 | PREHEATER RECYCLE GAS INLT/OUTL DIFFERENTIAL PRESSURE IND |
| PDI 419 | 112-1 | PREHEATER COED OIL INLT/OUTL DIFFERENTIAL PRESSURE INDICATOR |
| PDI 419A | 112-1 | PREHEATER COED OIL INLT/OUTL DIFFERENTIAL PRESSURE INDICATOR |
| PDI 420-1 | 112-2 | HYDRO TREATING REACTOR A/B INLETS D/P INDICATOR |
| PDI 420-2 | 112-2 | HYDRO TREATING REACTOR B LEVEL D/P INDICATOR |
| PDI 420-3 | 112-2 | HYDRO TREATING REACTOR B LEVEL D/P INDICATOR |
| PDI 421 | 112-2 | REACTOR BOTTOMS COOLER INLET/OUTLET DIFFERENTIAL PRESS IND |
| PDI 429 | 112-2 | VAPOR CONDENSER INLET/OUTLET DIFFERENTIAL PRESSURE INDICATOR |
| PDI 436 | 112-3 | ENTRAINMENT SEPARATOR INLET/OUTLET DIFFERENTIAL PRESSURE IND |
| PDIC 215V | 111-5 | PYROLYSIS GAS TO INCINERATOR INDICATING D/P CONTROLLER |
| PDR 002-1 | 112-2 | HYDRO TREATING REACTOR A/B INLETS D/P RECORDER CHART 1 |
| PDR 002-2 | 112-2 | HYDRO TREATING REACTOR LEVEL D/P RECORDER CHART 2 |
| PDR 002-3 | 112-2 | HYDRO TREATING REACTOR B LEVEL D/P RECORDER CHART 3 |
| PDT 317 | 111-8 | GAS LINE DIFFERENTIAL PRESSURE TRANSMITTER |
| PDT 418 | 112-1 | PREHEATER RECYCLE GAS INLT/OUTL DIFFERENTIAL PRESSURE XMTR |
| PDT 419A | 112-1 | PREHEATER COED OIL INLT/OUTL DIFFERENTIAL PRESS TRANSMITTER |
| PDT 420-1 | 112-2 | HYDRO TREATING REACTOR A/B INLETS D/P TRANSMITTER |
| PDT 420-2 | 112-2 | HYDRO TREATING REACTOR B LVL D/P TRANSMITTER |
| PDT 420-3 | 112-2 | HYDRO TREATING REACTOR B LEVEL D/P TRANSMITER |
| PDT 436 | 112-3 | ENTRAINMENT SEPARATOR INLT/OUTL DIFFERENTIAL PRESSURE XMTR |
| PI 002 | 111-3 | MAIN AIR CIRCULATING FAN DISCHARGE TO DUST COLLECTOR PRESS. |
| PI 003 | 111-3 | MAIN AIR CIRCULATING FAN DISCHARGE TO ROLLER MILL PRESSURE |
| PI 004 | 111-3 | MAIN AIR CIRCULATING FAN SUCTION PRESSURE |
| PI 005 | 111-3 | ROTARY DSCH VALVE SEAL PRESSURE |
| PI 006 | 111-3 | COMPRESSED AIR LINE PRESSURE |
| PI 007 | 111-3 | COMPRESSED AIR LINE PRESSURE |
| PI 008 | 111-4 | 10 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 009 | 111-4 | 10 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 010 | 111-4 | 1.5 KW RECYCLE GAS HEATER INLET PRESSURE |
| PI 011 | 111-4 | 1.5 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 012 | 111-4 | FINES FEEDER ROTARY VALVE SEAL PRESSURE INDICATOR |
| PI 013 | 111-4 | FIRST STAGE RECYCLE GAS COMPRESSOR DISCHARGE PRESS INDICATOR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PI 014 | 111-4 | FIRST STAGE PYROLYZER FLUID BED LO LVL PRESSURE INDICATOR |
| PI 015 | 111-4 | FIRST STAGE PYROLYZER PURGE LINE PRESS INDICATOR |
| PI 016 | 111-5 | VENTURI SCRUBBER COOLER SCRUB LIQUOR INLET PRESSURE IND |
| PI 017 | 111-5 | GAS LIQUID SEPARATOR SCRUB LIQUOR INLET PRESSURE INDICATOR |
| PI 018 | 111-5 | PYROLYSIS GAS TO INCINERATOR PRESSURE INDICATOR |
| PI 019A | 111-5 | RECYCLE LIQUOR PUMP A DISCHARGE PRESSURE INDICATOR |
| PI 019B | 111-5 | RECYCLE LIQUOR PUMP B DISCHARGE PRESSURE INDICATOR |
| PI 020 | 111-5 | FIRST STAGE OIL DEHYDRATOR MP STEAM INLET PRESS INDICATOR |
| PI 021A | 111-5 | FIRST STAGE OIL PUMP A DISCHARGE PRESSURE INDICATOR |
| PI 021B | 111-5 | FIRST STAGE OIL PUMP B DISCHARGE PRESSURE INDICATOR |
| PI 022 | 111-5 | FIRST STAGE OIL WEIGH TANK MED. PRESS. STEAM INLET PRESS IND |
| PI 030 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 031 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 032 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 033 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 034 | 111-6 | 30 KW REC CLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 035 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 036 | 111-6 | EXTERNAL CYCLONE DSCH NITROGEN PRESSURE INDICATOR |
| PI 040 | 111-7 | 10 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 041 | 111-7 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 042 | 111-7 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 043 | 111-7 | 30 KW RECYCLE GAS HEATER INLET PRESSURE INDICATOR |
| PI 044 | 111-7 | 25 KW OXYGEN HEATER INLET PRESSURE INDICATOR |
| PI 045 | 111-7 | 35 KW STEAM SUPERHEATER INLET PRESSURE INDICATOR |
| PI 046 | 111-7 | FOURTH STAGE PYROLYZER OXYGEN INLET PRESSURE INDICATOR |
| PI 047 | 111-7 | NITROGEN TO MIXING TEE 11 HEADER PRESSURE INDICATOR |
| PI 048 | 111-7 | MIXING TEE 11 NITROGEN INLET PRESSURE INDICATOR |
| PI 049 | 111-7 | CHAR STORAGE TANK OUTLET PRESSURE INDICATOR |
| PI 050 | 111-7 | CHAR CONVEYOR NITROGEN INLET PRESSURE INDICATOR |
| PI 060 | 111-8 | VENTURI SCRUBBER SCRUB LIQUOR INLET PRESSURE INDICATOR |
| PI 061 | 111-8 | GAS/LIQUID SEPARATOR SCRUB LIQUOR INLET PRESSURE INDICATOR |
| PI 062 | 111-8 | VENTURI DEMISTER SCRUB LIQUOR INLET PRESSURE INDICATOR |
| PI 063 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DISCHARGE PRESSURE IND |
| PI 064A | 111-9 | SCRUB LIQUOR PUMP A DISCHARGE PRESSURE INDICATOR |
| PI 064B | 111-9 | SCRUB LIQUOR PUMP B DISCHARGE PRESSURE INDICATOR |
| PI 065 | 111-9 | SCRUB LIQUOR PUMP A/B DISCHARGE HEADER PRESSURE INDICATOR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PI 066 | 111-9 | DECANTED OIL PUMP DISCHARGE PRESSURE INDICATOR |
| PI 067 | 111-9 | DEHYDRATED OIL PUMP DISCHARGE PRESSURE INDICATOR |
| PI 068 | 111-9 | DEHYDRATED PRODUCT OIL PUMP DISCHARGE PRESSURE INDICATOR |
| PI 069 | 111-9 | PRODUCT OIL TRANSFER PUMP DISCHARGE PRESSURE INDICATOR |
| PI 070 | 111-9 | HEAVY OIL DEHYDRATOR HEATING STEAM INLET PRESSURE INDICATOR |
| PI 071 | 111-9 | OIL DEHYDRATOR HEATING STEAM INLET PRESSURE INDICATOR |
| PI 072 | 111-9 | OIL STORAGE TANK A HEATING STEAM INLET PRESSURE INDICATOR |
| PI 073 | 111-9 | OIL STORAGE TANK B HEATING STEAM INLET PRESSURE INDICATOR |
| PI 074 | 111-9 | CRUDE PRODUCT PUMP DISCHARGE PRESSURE INDICATOR |
| PI 075A | 113-1 | COOLING TOWER PUMP A DISCHARGE PRESSURE INDICATOR |
| PI 075B | 113-1 | COOLING TOWER PUMP B DISCHARGE PRESSURE INDICATOR |
| PI 076A | 113-1 | CONDENSATE RETURN UNIT PUMP A DISCHARGE PRESSURE INDICATOR |
| PI 076B | 113-1 | CONDENSATE RETURN UNIT PUMP B DISCHARGE PRESSURE INDICATOR |
| PI 080 | 111-10 | PRECOAT TANK HEATING STEAM INLET PRESSURE INDICATOR |
| PI 081 | 111-10 | PRECOAT PUMP DISCHARGE PRESSURE INDICATOR |
| PI 082 | 111-10 | FILTER FEED TANK HEATING STEAM INLET PRESSURE INDICATOR |
| PI 083 | 111-10 | FILTER FEED PUMP DISCHARGE PRESSURE INDICATOR |
| PI 084 | 111-10 | FILTRATE RECEIVERS VENT HEADER PRESSURE INDICATOR |
| PI 085 | 111-10 | FILTERED OIL PRODUCT PUMP DISCHARGE PRESSURE INDICATOR |
| PI 086 | 111-7 | OXYGEN HEADER PRESSURE INDICATOR |
| PI 087 | 111-7 | OXYGEN HEADER PRESSURE INDICATOR |
| PI 090 | 113-1 | PLANT AIR HEADER PRESSURE INDICATOR |
| PI 100 | 112-1 | OIL FEED TANK A HEATING STEAM INLET PRESSURE INDICATOR |
| PI 101 | 112-1 | OIL FEED TANK B HEATING STEAM INLET PRESSURE INDICATOR |
| PI 102 | 112-1 | OIL FEED PUMP A DISCHARGE PRESSURE INDICATOR |
| PI 103 | 112-1 | OIL FEED PUMP B DISCHARGE PRESSURE INDICATOR |
| PI 104 | 112-1 | PREHEATER COED OIL INLET PRESSURE INDICATOR |
| PI 105 | 112-1 | PLANT AIR PRESSURE INDICATOR |
| PI 106 | 112-1 | MAIN STEAM PRESSURE INDICATOR |
| PI 107 | 112-1 | NITROGEN PRESSURE INDICATOR |
| PI 108 | 112-1 | REGENERATION HEADER PRESSURE INDICATOR |
| PI 109 | 112-1 | COED OIL HIGH PRESSURE VENT PRESSURE INDICATOR |
| PI 111 | 112-2 | HYDRO TREATING REACTOR A INLET PRESSURE INDICATOR |
| PI 113 | 112-2 | HYDRO TREATING REACTOR B INLET PRESSURE INDICATOR |
| PI 114 | 112-2 | HYDRO TREATING REACTOR B INTERSTAGE PRESSURE INDICATOR |
| PI 115 | 112-2 | HYDRO TREATING REACTOR B OUTLET PRESSURE INDICATOR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PI 116 | 112-2 | HI TEMP FLASH DRUM VAPOR OUTLET PRESSURE INDICATOR |
| PI 117 | 112-2 | LO TEMP FLASH DRUM VENT GAS OUTLET PRESSURE INDICATOR |
| PI 118 | 112-3 | ENTRAINMENT SEPARATOR OUTLET PRESSURE INDICATOR |
| PI 119 | 112-3 | HYDROGEN RECYCLE COMPRESSOR AFTERCOOLER OUTLET PRESSURE IND |
| PI 120 | 112-3 | PRODUCT OIL PUMP A DISCHARGE PRESSURE INDICATOR |
| PI 121 | 112-3 | PRODUCT OIL PUMP B DISCHARGE PRESSURE INDICATOR |
| PI 122 | 112-3 | HIGH PRESSURE WATER PUMP DISCHARGE PRESSURE INDICATOR |
| PI 123 | 112-3 | HYDROGEN RECYCLE COMPRESSOR HYDROGEN SUPPLY PRESSURE IND |
| PI 124 | 112-3 | MAKE-UP HYDROGEN COMPRESSOR DISCHARGE PRESSURE INDICATOR |
| PI 125 | 112-4 | OIL STORAGE TANK A HEATING STEAM INLET PRESSURE INDICATOR |
| PI 126 | 112-4 | OIL STORAGE TANK B HEATING STEAM INLET PRESSURE INDICATOR |
| PI 127 | 112-4 | OIL STORAGE TANK C HEATING STEAM INLET PRESSURE |
| PI 128 | 112-4 | HYDRO-TREATED OIL PUMP DISCHARGE PRESSURE INDICATOR |
| PI 129 | 112-3 | MAKE-UP HYDROGEN COMPRESSOR DISCHARGE PRESSURE INDICATOR |
| PI 130 | 112-1 | COED OIL PREHEATER COMB CONT PRESSURE INDICATOR |
| PI 132 | 112-3 | RECYCLE GAS PRESSURE INDICATOR |
| PI 133 | 112-3 | HYDROGEN RECYCLE COMPRESSOR SUCTION PRESSURE INDICATOR |
| PI 147 | 113-1 | INSTRUMENT AIR HEADER PRESSURE INDICATOR |
| PI 148 | 113-1 | INSTRUMENT AIR DRYER BED 1 PRESSURE INDICATOR |
| PI 149 | 113-1 | INSTRUMENT AIR DRYER BED 2 PRESSURE INDICATOR |
| PI 210 | 111-4 | FIRST STAGE PYROLYZER CYCLONE B PRESSURE INDICATOR |
| PI 220 | 111-6 | SECOND STAGE PYROLYZER CYCLONE B LVL PRESSURE INDICATOR |
| PI 230 | 111-6 | THIRD STAGE PYROLYZER CYCLONE B LVL PRESSURE INDICATOR |
| PI 240 | 111-7 | FOURTH STAGE PYROLYZER HI LVL VAPOR PRESSURE INDICATOR |
| PI 410 | 112-1 | PREHEATER COED OIL INLET PRESSURE INDICATOR |
| PI 419 | 112-2 | HYDRO TREATING REACTOR A INLET PRESSURE INDICATOR |
| PI 422 | 112-2 | HI TEMP FLASH DRUM VAPOR OUTLET PRESSURE INDICATOR |
| PI 437 | 112-3 | HYDROGEN RECYCLE COMPRESSOR DISCHARGE PRESSURE INDICATOR |
| PI 630 | 113-1 | COOLING TOWER PUMPS DISCHARGE HEADER PRESSURE INDICATOR |
| PIC 203 | 111-4 | NITROGEN START UP LINE PRESSURE REGULATOR |
| PIC 204 | 111-4 | 1 STAGE RECYCLE GAS COMPRESSOR DSCH BACK PRESS IND CONT |
| PIC 319 | 111-8 | SECOND STAGE GAS COMPRESSOR SUCTION IND PRESSURE CONTROL |
| PIC 321 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DSCH PRESS IND CONT |
| PIC 322 | 111-8 | SECOND STAGE RECYCLE GAS COMP DSCH/NITROGEN PRESS CONTROL |
| PIC 381 | 111-10 | ROTARY PRESSURE PRECOAT CRUDE OIL FILTER PRESS IND CONT |
| PR 001 | 111-4 | 1 STAGE RECYCLE GAS & INTERSTAGE COMP PRESS 2 CHART RCDR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PRC 466 | 112-3 | HYDROGEN MAKE-UP RECORDING PRESSURE CONTROL |
| PSD 001 | 111-3 | VELOCITY SEPARATOR DISCHARGE PRESSURE SAFETY DISK |
| PSD 002 | 111-3 | CYCLONE COLLECTOR PRESS SAFETY DISK |
| PSD 003 | 111-3 | DUST COLLECTOR PRESS SAFETY DISK |
| PSD 004 | 111-3 | PULVERIZED COAL STORAGE TANK PRESS SAFETY DISK |
| PSD 021 | 112-2 | HYDRO TREATING REACTOR DSCH PRESS SAFETY DISK |
| PSV 001 | 111-3 | CYCLONE COLLECTOR PRESS SAFETY VALVE |
| PSV 002 | 111-3 | DUST COLLECTOR PRESS SAFETY VALVE |
| PSV 004 | 111-4 | FIRST STAGE RECYCLE GAS COMP B DSCH SAFTY VALVE |
| PSV 005 | 111-5 | GAS COOLER COOLING WATER SUPPLY PRESSURE SAFETY VALVE |
| PSV 006 | 111-5 | RECYCLE LIQUOR COOLING WATER INLET SAFETY VALVE |
| PSV 007 | 111-4 | FIRST STAGE RECYCLE GAS COMPRESSOR A OIL COOLER INLET SV |
| PSV 008 | 111-4 | FIRST STAGE RECYCLE GAS COMP B OIL CLR INLT SAFETY VALVE |
| PSV 009 | 111-7 | CHAR COOLER COOLING WATER SUPPLY PRESSURE SAFETY VALVE |
| PSV 010 | 111-8 | GAS COOLER COOLING WATER SUPPLY PRESSURE SAFETY VALVE |
| PSV 011 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DSCH PRESS SAFETY VALVE |
| PSV 012 | 111-9 | SCRUB LIQUOR COOLER COOLING WATER SUPPLY PRESSURE SAFETY VLV |
| PSV 014 | 111-5 | PYROLYSIS GAS TO INCINERATOR PRESSURE SAFETY VALVE |
| PSV 015 | 111-7 | 25 KW OXYGEN HEATER INLET PRESSURE SAFETY VALVE |
| PSV 016 | 111-8 | SECOND STAGE RECYCLE GAS COMPR OIL CLR CLG WTR SPLY PR S VLV |
| PSV 030 | 112-1 | OIL FEED PUMP A DISCHARGE PRESSURE SAFETY VALVE |
| PSV 031 | 112-1 | OIL FEED PUMP B DISCHARGE PRESSURE SAFETY VALVE |
| PSV 032 | 112-1 | PREHEATER RECYCLE GAS INLET PRESSURE SAFETY VALVE |
| PSV 033 | 112-1 | PREHEATER COED OIL INLET PRESSURE SAFETY VALVE |
| PSV 034 | 112-2 | HYDRO TREATING REACTOR A INLET PRESSURE SAFETY VALVE |
| PSV 035 | 112-2 | HYDRO TREATING REACTOR B INLET PRESSURE SAFETY VALVE |
| PSV 036 | 112-2 | HI TEMP FLASH DRUM VAPOR OUTLET PRESSURE SAFETY VALVE |
| PSV 037 | 112-2 | LO TEMP FLASH DRUM VENT GAS OUTLET PRESSURE SAFETY VALVE |
| PSV 038 | 112-2 | REACTOR BOTTOMS COOLER COOLING WATER SUPPLY PRESS SAFETY VLV |
| PSV 039 | 112-2 | VAPOR CONDENSER COOLING WATER SUPPLY PRESSURE SAFETY VALVE |
| PSV 040 | 112-3 | HIGH PRESSURE WATER PUMP DISCHARGE PRESSURE SAFETY VALVE |
| PSV 043 | 112-2 | REACTOR BOTTOMS COOLER COOLING WATER SUPPLY PRESS SAFETY VLV |
| PSV 044 | 112-2 | REACTOR BOTTOMS COOLER COOLING WATER SUPPLY PRESS SAFETY VLV |
| PSV 045 | 112-3 | HYDROGEN RECYCLE COMPRESSOR CLG WTR SPLY PRESS SAFETY VLV |
| PSV 046 | 112-3 | HYDROGEN RECYCLE COMPRESSOR AFTERCOOLER OUTL PRESS SAF VLV |
| PSV 058 | 113-1 | INSTRUMENT AIR DRYER BED 1 RELIEF-VALVE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PSV 059 | 113-1 | INSTRUMENT AIR DRYER BED 2 RELIEF VALVE |
| PT 008 | 111-4 | 10 KW RECYCLE GAS HEATER INLET PRESSURE TRANSMITTER |
| PT 010 | 111-4 | 1.5 KW RECYCLE GAS HEATER INLET PRESSURE TRANSMITTER |
| PT 018 | 111-5 | PYROLYSIS GAS TO INCINERATOR PRESSURE TRANSMITTER |
| PT 030 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE TRANSMITTER |
| PT 032 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE TRANSMITTER |
| PT 034 | 111-6 | 30 KW RECYCLE GAS HEATER INLET PRESSURE TRANSMITTER |
| PT 040 | 111-7 | 10 KW RECYCLE GAS HEATER INLET PRESSURE TRANSMITTER |
| PT 042 | 111-7 | 30 KW RECYCLE GAS HEATER INLET PRESSURE TRANSMITTER |
| PT 046 | 111-7 | FOURTH STAGE PYROLYZER OXYGEN INLET PRESSURE TRANSMITTER |
| PT 087 | 111-7 | OXYGEN HEADER PRESSURE TRANSMITTER |
| PT 124 | 112-3 | MAKE-UP HYDROGEN COMPRESSOR DISCHARGE PRESSURE TRANSMITTER |
| PT 204 | 111-4 | FIRST STAGE RECYCLE GAS COMPRESSOR DSCH PRESS TRANSMITTER |
| PT 240 | 111-7 | FOURTH STAGE PYROLYZER HI LVL VAPOR PRESSURE TRANSMITTER |
| PT 319 | 111-8 | SECOND STAGE GAS COMPRESSOR SUCTION PRESSURE TRANSMITTER |
| PT 321 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DSCH PRESS TRANSMITTER |
| PT 410 | 112-1 | PREHEATER COED OIL INLET PRESSURE TRANSMITTER |
| PT 419 | 112-2 | HYDRO TREATING REACTOR A INLET PRESSURE TRANSMITTER |
| PT 422 | 112-2 | HI TEMP FLASH DRUM VAPOR OUTLET PRESSURE TRANSMITTER |
| PT 437 | 112-3 | HYDROGEN RECYCLE COMPRESSOR DISCHARGE PRESSURE TRANSMITTER |
| PT 466 | 112-3 | RECYCLE GAS PRESSURE TRANSMITTER |
| PT 630 | 113-1 | COOLING TOWER PUMPS DISCHARGE HEADER PRESSURE TRANSMITTER |
| S 410 A | 112-1 | OIL FEED PUMP A ON/OFF SWITCH |
| S 410B | 112-1 | OIL FEED PUMP B ON/OFF SWITCH |
| SV 021A | 111-5 | FIRST STAGE OIL PUMP A SUCTION VACUUM BREAKER SV |
| SV 021B | 111-5 | FIRST STAGE OIL PUMP B SUCTION VACUUM BREAKER SV |
| TA 131 | 111-3 | VELOCITY SEPARATOR TEMPERATURE |
| TA 133 | 111-3 | AIR HEATER DISCHARGE TEMPERATURE HI ALARM |
| TA 203 | 111-4 | FIRST STAGE PYROLYZER FLUIDIZING GAS HI TEMP ALARM |
| TA 419 | 112-1 | PREHEATER COED OIL TUBE WALL TEMPERATURE ALARM |
| TA 437 | 112-3 | HYDROGEN RECYCLE COMPRESSOR DISCHARGE TEMPERATURE ALARM |
| TC 003 | 111-4 | FIRST STAGE RECYCLE GAS COMP A DSCH TEMP CONT HI |
| TC 004 | 111-4 | FIRST STAGE RECYCLE GAS COMP B DSCH TEMP CONT LO |
| TC 009 | 111-4 | FIRST STAGE RECYCLE GAS COMP A OIL INLT TEMP CONT HI |
| TC 010 | 111-4 | FIRST STAGE RECYCLE GAS COMP B OIL INLT TEMP CONT HI |
| TC 021 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR OIL CLR OUTL TEMP CONT. |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TC 034 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DSCH TEMPERATURE CONT |
| TC 132 | 111-3 | VELOCITY SEPARATOR TEMPERATURE HI CONT |
| TI 002 | 111-4 | FIRST STAGE RECYCLE GAS COMP DSCH HEADER TEMP IND |
| TI 005 | 111-4 | FIRST STAGE RECYCLE GAS COMP A OIL OUTL TEMP IND |
| TI 006 | 111-4 | FIRST STAGE RECYCLE GAS COMP A OIL INLT TEMP IND |
| TI 007 | 111-4 | FIRST STAGE RECYCLE GAS COMP B OIL INLT TEMP IND |
| TI 008 | 111-4 | FIRST STAGE RECYCLE GAS COMP B OIL OUTL TEMP IND |
| TI 011 | 111-5 | RECYCLE LIQUOR COOLER OUTLET TEMPERATURE INDICATOR |
| TI 012 | 111-5 | RECYCLE LIQUOR COOLER COOLING WATER SUPPLY TEMPERATURE IND |
| TI 016 | 111-5 | OIL/WATER DECANTER HEAVY OIL TEMPERATURE INDICATOR |
| TI 017 | 111-5 | FIRST STAGE OIL DEHYDRATOR TEMPERATURE INDICATOR |
| TI 018 | 111-5 | FIRST STAGE OIL WEIGH TANK TEMPERATURE INDICATOR |
| TI 019 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR OIL COOLER INLT TEMP IND |
| TI 020 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR OIL COOLER OUTL TEMP IND |
| TI 027 | 111-7 | CHAR COOLER OUTLET TEMPERATURE INDICATOR |
| TI 029 | 111-7 | CHAR COOLER COOLING WATER RETURN TEMPERATURE INDICATOR |
| TI 030 | 111-7 | CHAR COOLER COOLING WATER TO DRAIN TEMPERATURE INDICATOR |
| TI 033 | 111-8 | SECOND STAGE RECYCLE GAS COMPRESSOR DSCH TEMPERATURE IND |
| TI 043 | 111-9 | SCRUB LIQUOR COOLER OUTLET TEMPERATURE INDICATOR |
| TI 044 | 111-9 | SCRUB LIQUOR COOLER CLG WATER SUPPLY TEMPERATURE INDICATOR |
| TI 046 | 111-9 | PRODUCT OIL WEIGH TANK TEMPERATURE INDICATOR |
| TI 047 | 111-10 | PRECOAT TANK TEMPERATURE INDICATOR |
| TI 048 | 111-10 | FILTER FEED TANK TEMPERATURE INDICATOR |
| TI 049 | 111-10 | FILTER FEED WEIGH TANK TEMPERATURE INDICATOR |
| TI 050 | 111-10 | ROTARY PRESSURE PRECOAT CRUDE OIL FILTER TEMPERATURE IND |
| TI 051 | 111-10 | FILTRATE RECEIVER OUTLET TEMPERATURE INDICATOR |
| TI 052 | 111-10 | FILTRATE RECEIVER TEMPERATURE INDICATOR |
| TI 053 | 111-10 | FILTRATE RECEIVERS VENT HEADER TEMPERATURE INDICATOR |
| TI 054 | 111-10 | FILTRATE HOLD TANK TEMPERATURE INDICATOR |
| TI 055 | 113-1 | COOLING TOWER PUMPS DISCHARGE HEADER TEMPERATURE INDICATOR |
| TI 080 | 112-2 | REACTOR BOTTOMS COOLER COOLING WATER RETURN TEMPERATURE IND |
| TI 081 | 112-2 | REACTOR BOTTOMS COOLER OUTLET TEMPERATURE INDICATOR |
| TI 082 | 112-2 | HI TEMP FLASH DRUM INLET TEMPERATURE INDICATOR |
| TI 083 | 112-2 | HI TEMP FLASH DRUM VAPOR OUTLET TEMPERATURE INDICATOR |
| TI 084 | 112-2 | VAPOR CONDENSER COOLING WATER RETURN TEMPERATURE INDICATOR |
| TI 085 | 112-2 | VAPOR CONDENSER OUTLET TEMPERATURE INDICATOR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TI 086 | 112-2 | LO TEMP FLASH DRUM INLET TEMPERATURE |
| TI 087 | 112-2 | LO TEMP FLASH DRUM VENT GAS OUTLET TEMPERATURE INDICATOR |
| TI 088 | 112-2 | LIGHT OIL WEIGH TANK TEMPERATURE INDICATOR |
| TI 089 | 112-3 | HEAVY OIL PRODUCT WEIGH TANK TEMPERATURE INDICATOR |
| TI 090 | 112-3 | HEAVY OIL PRODUCT WEIGH TANK TEMPERATURE INDICATOR |
| TI 095 | 113-1 | INSTRUMENT AIR DRYER BED 1 TEMPERATURE INDICATOR |
| TI 096 | 113-1 | INSTRUMENT AIR DRYER BED 2 TEMPERATURE INDICATOR |
| TI 300-05 | | VENTURI SCRUBBER COOLER PYROLYSIS GAS INLET TEMP INDICATOR |
| TI 300-06 | 111-5 | GAS LIQUID SEPARATOR PYROLYSIS GAS OUTLET TEMP INDICATOR |
| TI 300-07 | 111-5 | PYROLYSIS GAS TO INCINERATOR TEMPERATURE INDICATOR |
| TI 300-09 | 111-5 | OIL/WATER DECANTER TEMPERATURE INDICATOR |
| TI 300-1 | 111-4 | FIRST STAGE PYROLYZER CRUSHED COAL INLET TEMP INDICATOR REVIEWED 7/18. NO PROBLEMS |
| TI 300-10 | 111-5 | FIRST STAGE OIL DEHYDRATOR TEMPERATURE INDICATOR |
| TI 300 11 | 111-6 | SECOND STAGE PYROLYZER CRUSHED COAL INLET TEMP INDICATOR |
| TI 300-12 | 111-6 | SECOND STAGE PYROLYZER MIXED FINES INLET TEMPERATURE IND |
| TI 300-13 | 111-6 | SECOND STAGE PYROLYZER FINES INLET TEMPERATURE INDICATOR |
| TI 300-14 | 111-6 | THIRD STAGE PYROLYZER CRUSHED COAL INLET TEMPERATURE IND |
| TI 300-15 | 111-6 | THIRD STAGE PYROLYZER COAL/CHAR INLET TEMPERATURE INDICATOR |
| TI 300-16 | 111-7 | FOURTH STAGE PYROLYZER CHAR INLET TEMPERATURE INDICATOR |
| TI 300-17 | 111-6 | 30 KW RECYCLE GAS HEATER OUTLET TEMPERATURE INDICATOR |
| TI 300-18 | 111-6 | NO 6 MIXING TEE HOT GAS INLET TEMPERATURE INDICATOR |
| TI 300-19 | 111-6 | NO 4 MIXING TEE HOT GAS INLET TEMPPPATURE INDICATOR |
| TI 300-2 | 111-4 | EXTERNAL CYCLONE GAS INLET TEMPERATURE INDICATOR |
| TI 300-20 | 111-7 | PYROLYSIS GAS TEMPERATURE INDICATOR |
| TI 300-22 | 111-6 | FINES IN WEIGH TANK TEMPERATURE INDICATOR |
| TI 300-23 | 111-8 | VENTURI SCRUBBER PYROLYSIS GAS INLET TEMPERATURE INDICATOR |
| TI 300-24 | 111-8 | GAS/LIQUID SEPARATOR PYROLYSIS GAS OUTLET TEMPERATURE IND |
| TI 300-25 | 111-8 | GAS COOLER INLET TEMPERATURE INDICATOR |
| TI 300-26 | 111-8 | GAS/WATER SEPARATOR PYROLYSIS GAS OUTLET TEMPERATURE IND |
| TI 300-27 | 111-8 | RECYCLE GAS/NITROGEN TEMPERATURE INDICATOR |
| TI 300-28 | 111-9 | OIL/WATER DECANTER WATER TEMPERATURE INDICATOR |
| TI 300-29 | 111-9 | OIL/WATER DECANTER HEAVY OIL TEMPERATURE INDICATOR |
| TI 300-3 | 111-4 | 10 KW RECYCLE GAS HEATER OUTLET TEMPERATURE INDICATOR |
| TI 300-30 | 111-9 | HEAVY OIL DEHYDRATOR TEMPERATURE INDICATOR |
| TI 300-31 | 111-9 | OIL DEHYDRATOR TEMPERATURE INDICATOR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TI 300-32 | 111-3 | AIR HEATER DISCHARGE TEMPERATURE IND |
| TI 300-33 | 111-3 | VELOCITY SEPARATOR TEMP IND |
| TI 300-34 | 111-9 | OIL STORAGE TANK A TEMPERATURE INDICATOR |
| TI 300-35 | 111-9 | OIL STORAGE TANK B TEMPERATURE INDICATOR |
| TI 300-36 | 113-1 | COOLING TOWER PUMPS DISCHARGE HEADER TEMPERATURE INDICATOR |
| TI 300-4 | 111-4 | 1.5 KW RECYCLE GAS HEATER OUTLET TEMPERATURE INDICATOR |
| TI 500-1 | 112-1 | OIL FEED TANK A TEMPERATURE INDICATOR |
| TI 500-2 | 112-1 | OIL FEED TANK B TEMPERATURE INDICATOR |
| TI 500-3 | 112-2 | REACTOR BOTTOMS COOLER OUTLET TEMPERATURE INDICATOR |
| TI 500-4 | 112-2 | VAPOR CONDENSER OUTLET TEMPERATURE INDICATOR |
| TI 500-5 | 112-4 | OIL STORAGE TANK A TEMPERATURE INDICATOR |
| TI 500-6 | 112-4 | OIL STORAGE TANK B TEMPERATURE INDICATOR |
| TI 500-7 | 112-4 | OIL STORAGE TANK C TEMPERATURE INDICATOR |
| TIC 245 | 111-7 | 10 KW RECYCLE GAS HEATER OUTLET TEMPERATURE IND CONT |
| TIC 245C | 111-7 | 10 KW RECYCLE GAS HEATER HI SHEATH TEMP IND CONT |
| TIC 246 | 111-7 | 25 KW OXYGEN HEATER OUTLET TEMPERATURE IND CONTROL |
| TIC 246C | 111-7 | 25 KW OXYGEN HEATER HI SHEATH TEMPERATURE IND CONTROL |
| TIC 247 | 111-7 | 35 KW STEAM SUPERHEATER OUTLET TEMPERATURE IND CONTROL |
| TIC 340 | 111-9 | HEAVY OIL DEHYDRATOR TEMPERATURE INDICATING CONTROLLER |
| TIC 408 A | 112-1 | OIL FEED TANK A TEMPERATURE INDICATING CONTROLLER |
| TIC 408 B | 112-1 | OIL FEED TANK B TEMPERATURE INDICATING CONTROLLER |
| TIC 422 | 112-2 | HI TEMP FLASH DRUM INLET TEMPERATURE INDICATING CONTROLLER |
| TIC 460 | 112-4 | OIL STORAGE TANK A TEMPERATURE INDICATOR CONTROLLER |
| TIC 461 | 112-4 | OIL STORAGE TANK B TEMPERATURE INDICATING CONTROLLER |
| TIC 462 | 112-4 | OIL STORAGE TANK C TEMPERATURE INDICATING CONTROLLER |
| TR 200-02 | 111-4 | FIRST STAGE PYROLYZER LVL B VAPOR TEMP RECORDER |
| TR 200-03 | 111-4 | FIRST STAGE PYROLYZER FLUID BED LO LVL TEMP RECORDER |
| TR 200-04 | 111-4 | FIRST STAGE PYROLYZER FLUIDIZING GAS TEMP RECORDER |
| TR 200-05 | 111-6 | SECOND STAGE PYROLYZER PYROLYSIS GAS OUTLET TEMP RECORDER |
| TR 200-06 | 111-6 | SECOND STAGE PYROLYZER CYCLONE A LVL VAPOR TEMP RECORDER |
| TR 200-07 | 111-6 | SECOND STAGE PYROLYZER FLUID BED HI LVL TEMP RECORDER |
| TR 200-08 | 111-6 | SECOND STAGE PYROLYZER FLUID BED MID LEVEL TEMP INDICATOR |
| TR 200-09 | 111-6 | SECOND STAGE PYROLYZER PYROLYSIS GAS INLET TEMPERATURE RCDR |
| TR 200-10 | 111-6 | THIRD STAGE PYROLYZER VAPOR LVL 2 TEMP RECORDER |
| TR 200 11 | 111-6 | THIRD STAGE PYROLYZER VAPOR LVL 1 TEMP RECORDER |
| TR 200-12 | 111-6 | THIRD STAGE PYROLYZER FLUID BED HI LVL TEMP RECORDER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TR 200-13 | 111-6 | THIRD STAGE PYROLYZER PYROLYSIS GAS INLET TEMPERATURE RCDR |
| TR 200-14 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED HI LVL TEMP RECORDER |
| TR 200-15 | 111-7 | FOURTH STAGE PYROLYZER BED BOTTOM TEMPERATURE RECORDER |
| TR 200-16 | 111-7 | FOURTH STAGE PYROLYZER ASH PIT TEMPERATURE RECORDER |
| TR 200-17 | 111-7 | FOURTH STAGE PYROLYZER OXYGEN INLET TEMPERATURE RECORDER |
| TR 200-2 | 111-4 | FIRST STAGE PYROLYZER LVL B VAPOR TEMP RECORDER |
| TR 200-3 | 111-4 | FIRST STAGE PYROLYZER FLUID BED LO LVL TEMP RECORDER |
| TR 200-4 | 111-4 | FIRST STAGE PYROLYZER FLUIDIZING GAS TEMP RECORDER |
| TR 400-01 | 112-2 | HYDRO TREATING REACTOR A TEMPERATURE RECORDER CHART 1 |
| TR 400 11 | 112-2 | HYDRO TREATING REACTOR B SECT A TEMPERATURE RCDR CHART 11 |
| TR 400-12 | 112-2 | HYDRO TREATING REACTOR B SECT B TEMPERATURE RCDR CHART 12 |
| TR 400-5 | 112-2 | HYDRO TREATING REACTOR A TEMPERATURE RECORDER CHART 5 |
| TR 400-6 | 112-2 | HYDRO TREATING REACTOR A TEMPERATURE RECORDER CHART 6 |
| TR 400-7 | 112-2 | HYDRO TREATING REACTOR B SECT A TEMPERATURE RCDR CHART 7 |
| TR 400-8 | 112-2 | HYDRO TREATING REACTOR B SECT B TEMPERATURE RCDR CHART 8 |
| TR 400-9 | 112-2 | HYDRO TREATING REACTOR A TEMPERATURE RECORDER CHART 9 |
| TR 401-1 | 112-2 | HYDRO TREATING REACTOR B INLET TEMPERATURE RECORDER CHART 1 |
| TR 401-2 | 112-1 | PREHEATER COED OIL INLET TEMPERATURE RECORDER |
| TR 401-3 | 112-2 | HYDRO TREATING REACTOR A INLET TEMPERATURE RECORDER CHART 3 |
| TR 401-4 | 112-1 | PREHEATER STACK TEMPERATURE RECORDER |
| TR 401-5 | 112-1 | PREHEATER RECYCLE GAS OUTLET TEMPERATURE RECORDER |
| TR 401-6 | 112-2 | HYDRO TREATING REACTOR B INLET TEMPERATURE RECORDER CHART 4 |
| TR 401-7 | 112-2 | HYDRO TREATING REACTOR B OUTLET TEMPERATURE RECORDER CHART 7 |
| TR 401-8 | 112-3 | HYDROGEN RECYCLE COMPRESSOR DISCHARGE TEMP RCDR CHART 8 |
| TRC 130 | 111-3 | VELOCITY SEPARATOR TEMPERATURE RECORDER |
| TRC 210 | 111-4 | FIRST STAGE PYROLYZER FLUID BED MID LVL TEMP RECORDER |
| TRC 220 | 111-6 | SECOND STAGE PYROLYZER FLUID BED HI LVL REC TEMP CONTRO |
| TRC 230 | 111-6 | THIRD STAGE PYROLYZER FLUID BED RECORDING TEMP CONTROLLER |
| TRC 240 | 111-7 | FOURTH STAGE PYROLYZER ASH PIT TEMPERATURE RECORDING CONTROL |
| TRC 419 | 112-1 | PREHEATER COED OIL OUTLET TEMPERATURE RECORDING CONTROLLER |
| TT 205 | 111-4 | 10 KW RECYCLE GAS HEATER OUTLET TEMPERATURE TRANSMITTER |
| TT 210 | 111-4 | FIRST STAGE PYROLYZER FLUID BED MID LVL TEMP TRANSMITTER |
| TT 219 | 111-4 | 1.5 KW RECYCLE GAS HEATER OUTLET TEMPERATURE TRANSMITTER |
| TT 240 | 111-7 | FOURTH STAGE PYROLYZER ASH PIT TEMPERATURE TRANSMITTER |
| TT 245 | 111-7 | 10 KW RECYCLE GAS HEATER OUTLET TEMPERATURE TRANSMITTER |
| TT 246 | 111-7 | 25 KW OXYGEN HEATER OUTLET TEMPERATURE TRANSMITTER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TT 247 | 111-7 | 35 KW STEAM SUPERHEATER OUTLET TEMPERATURE TRANSMITTER |
| TT 248 | 111-7 | 30 KW RECYCLE GAS HEATER OUTLET TEMPERATURE TRANSMITTER |
| TT 419 | 112-1 | PREHEATER COED OIL OUTLET TEMPERATURE TRANSMITTER |
| TT 422 | 112-2 | HI TEMP FLASH DRUM INLET TEMPERATURE TRANSMITTER |
| TW 013 | 111-5 | RECYCLE LIQUOR COOLER COOLING WATER RETURN TEMP TEST WELL |
| TW 014 | 111-5 | RECYCLE LIQUOR PUMPS DISCHARGE HEADER TEMPERATURE TEST WELL |
| TW 015 | 111-5 | GAS COOLER COOLING WATER RETURN TEMPERATURE TEST WELL |
| TW 032 | 111-8 | GAS COOLER COOLING WATER RETURN TEMPERATURE TEST WELL |
| TW 042 | 111-9 | SCRUB LIQUOR COOLER INLET TEMPERATURE TEST WELL |
| TW 045 | 111-9 | SCRUB LIQUOR COOLER COOLING WATER RETURN TEMPERATURE TEST |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET SEC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AIT 1000 | 201 | DRYER FURNACE STACK 02 ANALYTICAL INDICATING TRANSMITTER |
| AIT 1001 | 202 | 02 IND ANALYTICAL XMTR |
| AM 1000 | 201 | DRYER FURNACE STACK 02 ANALYTICAL RECORDER SIGNAL CONVERTOR |
| AM 1001 | 202 | 02 ANALYTICAL SIGNAL XVERTOR |
| AM 2001 | 205 | RG CYCLONE FLUE GAS OUTL 02 ANALYSIS XDCR |
| AM 2002 | 205 | RG CYCLONE FLUE GAS OUTL CO ANALYSIS XDCR |
| AM 2002 A | 205 | RG CYCLONE FLUE GAS OUTL CO ANALYSIS XDCR A |
| AR 1000 | 201 | DRYER FURNACE STACK 02 RECORDER |
| AR 1000A | 202 | 02 ANALYTICAL RCDR |
| AR 1001 | 201 | DRYER FURNACE STACK 02 ANALYTICAL RECORDER LOCAL PANEL |
| AR 1001A | 202 | 02 ANALYTICAL RECORDER |
| AR 2001 | 205 | RG CYCLONE FLUE GAS OUTL 02 ANALYSIS REC |
| AR 2002 | 205 | RG CYCLONE FLUE GAS OUTL CO ANALYSIS REC |
| ARO 1023 | 201 | DRYER FURNACE FUEL GAS INLET ADJUSTABLE RESTRICTION ORIFICE |
| ARO 2140 | 202 | EQUALIZING HDR VENT ADJ RSTRCT ORIF |
| ARO 2141 | 202 | LIGNITE IN HOPPER VENT GAS ADJUSTABLE RESTRICTION ORIFICE |
| ARO 2187 | 204-2 | DV CYCLE COMP ADJ REST ORIF |
| ASH 1001 | 202 | 02 ANALYTICAL SWITCH HI |
| CCS 1000 | 201 | DRYER FURNACE COMBUSTION CONTROL SWITCH |
| CCS 1001 | 202 | PRHTR FURNACE COMBUSTION CONTROL SW |
| CCS 2001 | 204-1 | AIR HEATER PILOT SAFETY CONTROL VALVE |
| CCS 2003 | 204-1 | DOLOMITE LIFT HTR COMBUSTION CONT SW |
| CCS 2004 | 204-1 | CHAR LIFT HEATER COMBUSTION CONT SW |
| CE 1000 | 201 | DRYER FURNACE COMBUSTION ELEMENT IGNITOR |
| CE 1001 | 202 | PRHTR FURNACE INERT GAS INLET COMBUSTION ELMT |
| CE 1003 | 201 | DRYER FURNACE STACK IGNITOR IGNITOR |
| CE 2001 | 204-1 | AIR HEATER COMBUSTION ELEMENT |
| CE 2003 | 204-1 | DOLOMITE LIFT HTR COMBUSTION ELMT |
| CE 2004 | 204-1 | CHAR LIFT HEATER COMBUSTION ELMT |
| CSV 1000 | 201 | DRYER FURNACE FUEL GAS INLET COMBUSTION SAFETY VALVE STANDARD BLEED VALVE WITH DOUBLE BLOCK VALVES |
| CSV 1001A | 202 | PRHTR FURNACE TEMP CONT SOL VLV |
| CSV 1001B | 202 | PRHTR FURNACE FUEL GAS INLT SOLENOID VALVE |
| CSV 1002 | 201 | DRYER FURNACE FUEL GAS COMBUSTION SAFETY VALVE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| CSV 2001B | 204-1 | AIR HEATER FUEL GAS SAFETY SOL VLV A |
| CSV 2003A | 204-1 | DOLOMITE LIFT HTR FUEL GAS CONT SOL VLV |
| CSV 2003B | 204-1 | DOLOMITE LIFT HTR FUEL GAS INLT CONT SOL VLV |
| CSV 2004A | 204-1 | CHAR LIFT HEATER GAS SAFETY SHUT OFF VLV |
| CSV 2004B | 204-1 | CHAR LIFT HEATER GAS SAFETY SHUT OFF VALVE |
| CV 001 | 205 | ASH OUT HOPPER B INLT CONT VLV |
| CV 002 | 205 | ASH OUT HOPPER A INLT CONTROL VALVE |
| CVS 2001A | 204-1 | AIR HEATER FUEL GAS SAFETY SOL VLV A |
| DPCV 1003 | 202 | FURNACE PILOT D/P CONT VLV |
| DPCV 1005 | 201 | DRYER FURNACE FUEL GAS INLET D/P CONTROL VALVE |
| DPCV 1006 | 203-2 | HOT LIGNITE FEEDER PURGE D/P CONT VALVE |
| DPCV 1010 | 202 | IGNITOR AIR LINE D/P CONT VLV |
| DPCV 2000 | 207 | QUENCHED GAS STRM 1 DIFFL PRESS CONT VLV<br>EASY SERVICE-MINOR EROSION<br>THROTTLE PLUG,GATE OR BALL ALL OK |
| DPCV 2006 | 203-1 | SPENT DOLOMITE LINE VALVE PURGE GAS D/P CONTROL VALVE |
| DPCV 2007 | 203-1 | PURGE GAS SUPPLY D/P CONTROL VALVE |
| DPCV 2010 | 203-1 | DOLOMITE LINE RECYCLE FLUE GAS D/P CONTROL VALVE |
| DPCV 2026 | 203-1 | DOLOMITE DSCH LINE D/P CONTROL VALVE |
| DPCV 2030 | 202 | QUENCHED FLUE GAS D/P CONT VLV |
| DPCV 2030A | 202 | QUENCHED FLUE GAS D/P CONT VLV |
| DPCV 2036 | 203-1 | COKE LINE DIFFERENTIAL PRESSURE CONTROL VALVE |
| DPCV 2037 | 203-1 | PURGE GAS FOR SPEND DOLOMITE VALVE D/P CONTROL VALVE |
| DPCV 2050 | 202 | LIGNITE HOPPER PURGE GAS D/P CONT VLV |
| DPCV 2051 | 202 | FEEDER B PURGE D/P CONT VLV |
| DPCV 2055 | 203-2 | PURGE GAS D/P CONT VLV |
| DPCV 2056 | 203-2 | PURGE GAS D/P CONT VLV |
| DPCV 2057 | 203-2 | PURGE GAS D/P CONT VLV |
| DPCV 2071 | 202 | LIGNITE HOPPER PURGE GAS D/P CONT VLV |
| DPCV 2072 | 202 | LIGNITE FDR B PURGE GAS D/P CONT VLV |
| DPI 1004 | 202 | WASTE LIGNITE LINE D,P IND |
| DPI 1007 | 201 | WILLIAMS MILL/SEPARATOR/FEEDER D/P INDICATOR |
| DPI 1008 | 201 | BAG HOUSE DIFFERENTIAL PRESSURE INDICATOR |
| DPI 2011 | 203-1 | DIFFERENTIAL PRESSURE OVER DOLOMITE OUT HOPPER INDICATOR |
| DPI 2061 | 204-1 | MAIN AIR COMP LUBE OIL FILTER D/P IND |
| DPI 3008 | 208 | HPC ABSORBER DIFFERENTIAL PRESS IND<br>STD DEVICE |

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INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| DPI 3009 | 208 | HPC FILTER DIFFL PRESS IND<br>STD DEVICE |
| DPI 3010 | 208 | HPC STRIPPER DIFF PRESS IND<br>STD DEVICE |
| DPIC 2071 | 202 | LIGNITE HOPPER PURGE D/P IND CONT |
| DPIC 2072 | 202 | LIGNITE FDR B D/P IND CONT |
| DPIE 2038 | 202 | LIGNITE HOPPERS D/P IND SW HI/LO |
| DPIS 2038 | 203-2 | LIGNITE FEED LINE B D/P IND SW |
| DPIS 2039 | 202 | LIGNITE FDR B D/P IND SW HI/LO |
| DPIS 2039A | 203-2 | LIGNITE FEED LINE A D/P IND SW |
| DPIS 2039B | 203-2 | LIGNITE HOPPERS PURGE LINE D/P IND SW |
| DPR 1001 | 202 | LIGNITE PRHTR BED LVL D/P RCDR |
| DPR 1002 | 202 | LIGNITE PRHTR BED LVL D/P RCDR |
| DPR 1003 | 202 | LIGNITE PRHTR BED LVL D/P RCDR |
| DPR 2001 | 203-1 | DEVOLATILIZER FLUID BED D/P RECORDER |
| DPR 2002 | 203-1 | DEVOLATILIZER FLUID BED LEVEL D/P RECORDER |
| DPR 2003 | 203-1 | DEVOLATILIZER FLUID BED LEVEL D/P RECORDER |
| DPR 2004 | 203-1 | DEVOLATILIZER DOLOMITE POT D/P RECORDER |
| DPR 2005 | 203-1 | DEVOLATILIZER DOLOMITE POT D/P RECORDER |
| DPR 2008 | 203-1 | DOLOMITE LINE DIFFERENTIAL PRESSURE RECORDER |
| DPR 2009 | 203-1 | DOLOMITE LINE D/P RECORDER |
| DPR 2013 | 203-1 | COKE/CHAR LIFT LINE D/P RECORDER |
| DPR 2014 | 203-1 | GASIFIER CHAR DSCH LINE DIFFERENTIAL PRESS RECORDER |
| DPR 2021 | 203-1 | SPENT DOLOMITE/LIFT GAS D/P RECORDER |
| DPR 2022 | 203-1 | SPENT DOLOMITE DSCH LINE D/P RECORDER |
| DPR 2025 | 203-1 | DOLOMITE SUPPLY LINE D/P RECORDER |
| DPR 2027 | 203-1 | SPENT CHAR LINE DIFFERENTIAL PRESSURE RECORDER |
| DPR 2028 | 203-1 | SPENT CHAR LINE DIFFERENTIAL PRESSURE RECORDER |
| DPR 2029 | 203-1 | SPENT CHAR DSCH LINE DIFFERENTIAL PRESSURE RECORDER |
| DPR 2031 | 203-1 | GASIFIER BED LEVEL DIFFERENTIAL PRESSURE RECORDER |
| DPR 2032 | 203-1 | GASIFIER FLUID BED LEVEL D/P RECORDER |
| DPR 2033 | 203-1 | GASIFIER FLUID BED LEVEL D/P RECORDER |
| DPR 2034 | 203-1 | GASIFIER SPENT DOLOMITE BED D/P RECORDER |
| DPR 2035 | 203-1 | GASIFIER SPENT DOLOMITE BED D/P TRANSMITTER |
| DPR 2043 | 203-1 | DEVOLATILIZER RECYCLE GAS/PROCESS GAS DSCH D/P RECORDER |
| DPR 2044 | 203-1 | PROCESS GAS 1/2 DIFFERENTIAL PRESSURE RECORDER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SFC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| DPRC 2000 | 203-1 | DEVOLATILIZER VAPOR SPACE/FLUE GAS D/P RECORDING CONTROLLER |
| DPRC 2006 | 203-1 | SPENT DOLOMITE LINE VALVE PURGE GAS D/P RECORDING CONTROLLER |
| DPRC 2007 | 203-1 | PURGE GAS SUPPLY D/P REGULATING CONTROL |
| DPRC 2010 | 203-1 | DOLOMITE LINE RECYCLE GAS D/P REGULATING CONTROL |
| DPRC 2026 | 203-1 | GASIFIER DOLOMITE SUPLY LINE D/P RECORDING CONTROLLER |
| DPRC 2030 | 203-1 | PROCESS GAS 1/2 D/P RECORDING CONTROLLER |
| DPRC 2036 | 203-1 | COKE LINE DIFFERENTIAL PRESSURE RECORDING CONTROLLER |
| DPRC 2037 | 203-1 | PURGE GAS D/P RECORDING CONTROLLER |
| DPS 1000 | 201 | WILLIAMS MILL/SEPARATOR/FEEDER D/P SWITCH<br>NO CONTROL SHOWN |
| DPS 1001 | 202 | LIGNITE PRHTR BED LVL D/P SW LO |
| DPS 1003 | 202 | LIGNITE PRHTR BED LVL D/P SW HI |
| DPS 2002 | 203-1 | DEVOLATILIZER FLUID BED LEVEL D/P SWITCH |
| DPS 2026 | 203-1 | GASIFIER DOLOMITE SUPPLY D/P SWITCH HI-LO |
| DPS 2030 | 203-1 | PROCESS GAS 1/2 DIFFERENTIAL PRESSURE SWITCH H/L |
| DPS 2032 | 203-1 | GASIFIER FLUID BED LEVEL D/P SWITCH |
| DPSH 1011 | 201 | BAG HOUSE HIGH DIFFERENTIAL PRESSURE-START CARRIAGE MOTOR |
| DPSH 2003 | 203-1 | DEVOLATILIZER FLUID BED LEVEL D/P SWITCH HIGH |
| DPSH 2033 | 203-1 | GASIFIER FLUID BED LEVEL D/P SWITCH HIGH |
| DPSH 3001 | 205 | RG QUENCH PMPS DSCH HDR FLTR DIFFL PRESS SW HI |
| DPSH 3002 | 206 | GF QUENCH STRAINER HI DIFFL PRESS SW |
| DPSH 3003 | 207 | DV RECYCLE FILTER HI DIFFL PRESS SW<br>GENERALLY S.O.P. |
| DPSH 3004 | 207 | DV QUENCH PMPS DISCH FILTER HI DIFFL PRESS SW<br>S.O.P |
| DPSHL 2000 | 203-1 | DEVOLATILIZER TOP/FLUE GAS D/P SWITCH HIGH/LOW |
| DPSL 1012 | 201 | BAG HOUSE LOW DIFFERENTIAL PRESSURE-STOP CARRIAGE MOTOR |
| DPSL 2028 | 203-1 | SPENT CHAR LINE DIFFERENTIAL PRESSURE SWITCH LOW |
| DPSL 2046L | 203-2 | DEVOLATILIZER BED LEVEL D/P SWITCH LO |
| DPSL 2048L | 203-2 | REGENERATOR/GASIFIER D/P LINE D/P SW LO |
| DPSL 2049D | 203-2 | DEVOLATLIZER/GASIFIER D/P LINE PURGE D/P SW LO |
| DPSL 2049L | 203-2 | GASIFIER BED LEVEL D/P SW LO |
| DPSL 2053 | 202 | EQUALIZING HDR D/P SW LO |
| DPSL 2054 | 202 | LIGNITE FDR B D/P PURGE SW LO |
| DPT 1002 | 202 | LIGNITE PRHTR BED LVL D/P XMTR |
| DPT 2000H | 203-2 | DEVOLATILIZER BED LEVEL D/P XMTR LO |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| DPT 2000L | 203-2 | GASIFIER BED LEVEL D/P XMTR |
| DPT 2018 | 203-2 | REGENERATOR PURGE LINE D/P XMTR |
| DPT 2019 | 203-2 | DOLOMITE FDR/REGENERATOR D/P XMTR |
| DPT 2020 | 203-2 | REGENERATOR BED LEVEL D/P XMTR |
| DPT 2024 | 203-2 | DEVOLATILIZER/GASIFIER D/P LINE PURGE D/P XMTR |
| DPT 2027B | 203-2 | SPENT CHAR LINE D/P XMTR |
| DPT 2036B | 203-2 | GASIFIER SPENT CHAR LINE PURGE D/P XMTR |
| DPT 2043H | 203-2 | DEVOLATILIZER BED LEVEL D/P XMTR HI |
| DPT 2071 | 202 | LIGNITE HOPPERS D/P XMTR |
| DPT 2072 | 202 | LIGNITE FDR B D/P XMTR |
| EDV 2051 | 202 | QUENCHED FLUE GAS SOL VLV |
| EHC 1016 | 201 | BELT FEEDER MOTOR ELECTRICAL HAND CONTROLLER |
| EHC 1019 | 201 | DOLOMITE VIBRATING FEEDER B MOTOR ELECTRICAL HAND CONTROLLER |
| EHC 1020 | 201 | DOLOMITE VIBRATING FEEDER A MOTOR ELECTRICAL HAND CONTROLLER |
| EHC 1023 | 201 | LIGNITE CRUSHER FEEDER MOTOR ELECTRICAL HAND CONTROLLER |
| EHC 1025 | 201 | DOLOMITE SCREEN AND BUCKET ELEVATOR MOTORS ELEC HAND CONTROL |
| EHC 2054 | 202 | LIGNITE DSCH VLV MTR ELEC HAND CONT |
| EHC 2055 | 202 | LIGNITE FDR B DSCH VLV ELEC HAND CONT |
| EHC 2056 | 203-1 | DOLOMITE OUT HOPPER DSCH ROTARY VALVE MOTOR ELECT HAND SW |
| EHS 1001 | 201 | INERT GAS OUT LINE FROM WILLIAMS MILL VALVE MOTER HAND SW |
| EHS 1009 | 202 | INERT GAS CV ELEC HAND SW |
| EHS 1013 | 201 | LIGNITE SURGE BIN INLET CONTROL VALVE ELECTRICAL HAND SWITCH |
| EHS 1015 | 202 | HOT LIGNITE FEEDER MOTOR ELEC HAND SW |
| EHS 1016 | 201 | BELT FEEDER MOTOR ELECTRICAL HAND SWITCH |
| EHS 1017 | 201 | LIGNITE CRUSHER FEEDER MOTOR ELECTRICAL HAND SWITCH |
| EHS 1019 | 201 | DOLOMITE VIBRATING FEEDER B MOTOR ELECTRICAL HAND SWITCH |
| EHS 1020 | 201 | DOLOMITE VIBRATING FEEDER A MOTOR ELECTRICAL HAND SWITCH |
| EHS 1023 | 201 | LIGNITE CRUSHER FEEDER MOTOR ELECTRICAL HAND SWITCH |
| EHS 1024 | 201 | LIGNITE CRUSHER MOTOR ELECTRICAL HAND SWITCH |
| EHS 1026 | 201 | AIR FAN MOTOR START/STOP SELECTOR SWITCH |
| EHS 1027 | 201 | DRY LIGNITE FEEDER ELECTRICAL HAND SWITCH |
| EHS 1029 | 201 | MAIN FAN MOTOR START/STOP SELECTOR SWITCH |
| EHS 1031 | 201 | LIGNITE REDLER ELEVATOR MOTOR ELECTRICAL HAND SWITCH |
| EHS 1032 | 202 | ROOTS COMPRESSOR MOTOR ELEC HAND SW |
| EHS 1035 | 201 | SECONDARY FAN MOTOR START/STOP SELECTOR SWITCH |
| EHS 1043 | 201 | WILLIAMS MILL MOTOR ELECTRICAL HAND SWITCH |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| EHS 1051 | 201 | DRY LIGNITE FEEDER LN A ROTARY VALVE CONT ELEC HAND SWITCH |
| EHS 1052 | 201 | LIGNITE CYCLONE INLET INERT GAS SUPPLY CONTROL VLV ELEC SW |
| EHS 2000 | 203-1 | DEVOLATILIZER WASTE GAS VALVE ELEC HAND SW |
| EHS 2001 | 203-1 | SPENT DOLOMITE LINE VALVE MANUAL ELECTRIC SWITCH |
| EHS 2002 | 203-1 | COKE DISCHARGE LINE VALVE ELECTRICAL HAND SWITCH |
| EHS 2003 | 203-1 | GASIFIER SPENT DOLOMITE LINE ELECTRIC HAND SWITCH |
| EHS 2004 | 203-1 | DUMP HOPPER INLET CONT VLV ELECTRIC HAND SWITCH |
| EHS 201T | 203-1 | DEVOLATILIZER HEATER ELECTRIC HAND SWITCH |
| EHS 2010 | 203-1 | SPENT DOLOMITE DSCH CV HAND OPTD ELECTRIC SWITCH |
| EHS 2013 | 203-1 | GASIFIER COKE DSCH LINE VALVE ELECTRICAL HAND SWITCH |
| EHS 2014 | 203-1 | DEVOLATILIZER PROCESS GAS SOLENOID VALVE ELEC HAND CONTROL |
| EHS 202T | 203-1 | GASIFIER ELECTRICAL HAND SWITCH<br>TIED TO A GASIFIER DEVICE WHICH WAS DISCONNECTED OR REMOVED |
| EHS 2022 | 204-1 | AIR HEATER INLET AIR ELEC SW |
| EHS 2023 | 204-1 | CHAR LIFT HEATER RECYCLE GAS VALVE MANUAL ELECT SWITCH |
| EHS 2024 | 204-2 | RECYCLE GAS 2 VLV CONT ELEC SW |
| EHS 2026 | 204-2 | RECYCLE GAS 1 CONT ELEC SW |
| EHS 2030 | 203-1 | DOLOMITE SUPPLY CONTROL VALVE ELECTRICAL HAND SWITCH |
| EHS 2041 | 204-1 | DOLOMITE LIFT GAS HTR LIFT GAS INLT CV ELEC MANUAL SW |
| EHS 2059A | 205 | ASH OUT HOPPER A INLET CV ELEC HAND SW |
| EHS 2059B | 205 | ASH OUT HOPPER A OUTL CV ELEC HAND SW |
| EHS 2060A | 205 | ASH OUT HOPPER B OUTL CV ELEC HAND SW |
| EHS 2060B | 205 | ASH OUT HOPPER B OUTL CV ELEC HAND SW |
| EHS 2062 | 204-1 | RECYCLE FLUE GAS COMP A ELEC HAND SW |
| EHS 2063 | 204-1 | RECYCLE FLUE GAS COMP B MOTOR ELEC HAND SW |
| EHS 2066 | 202 | LIGNITE HOPPER B ELEC HAND SW |
| EHS 2076 | 204-2 | DV CYCLE COMP A MOTOR ELEC SW |
| EHS 2077 | 204-2 | DV CYCLE COMP B MOTOR ELEC SW |
| EHS 2078 | 204-2 | QUENCHED FUEL GAS COMP A MOTOR ELEC SW |
| EHS 2079 | 204-2 | RECYCLE FLUE GAS COMPRESSOR B MOTOR ELEC SW |
| EHS 2080 | 203-3 | DV JACKET WATER CIRC PUMP MOTOR MANUAL SW |
| EHS 2081 | 203-3 | RG JACKET WATER CIRC PUMP MOTOR MANUAL SW |
| EHS 2082 | 203-3 | CIRC PUMP B MOTOR MANUAL SW |
| EHS 2083 | 203-3 | RG JACKET WATER CIRC PUMP MOTOR A MANUAL SW |
| EHS 2084 | 203-3 | RG JACKET WATER CIRC PUMP MOTOR B MANUAL SW |
| EHS 2085 | 202 | LIGNITE HOPPER INLT VALVE ELECT HAND SW |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| EHS 2097 | 205 | ASH OUT HOPPER A RELIEF VENT GAS CV ELEC HAND SW |
| EHS 2098 | 205 | ASH OUT HOPPER B RELIEF VENT GAS CV ELEC HAND SW |
| EHS 3001 | 208 | RECYCLE CO2 COMPRESSOR ELEC HAND SW<br>STD APPLICATION |
| EI 1006 | 201 | AIR FAN MOTOR AMMETER |
| EI 1007 | 201 | MAIN AIR FAN MOTOR AMMETER |
| EI 1034 | 201 | SECONDARY FAN MOTOR AMMETER |
| EI 1040 | 201 | LIGNITE REDLER ELEVATOR MOTOR AMMETER |
| EI 1045 | 201 | WILLIAMS MILL MOTOR AMMETER |
| EI 1053 | 201 | DOLOMITE CRUSHER FEEDER MOTOR AMMETER |
| EI 1054 | 201 | DOLOMITE SCREW CONVEYOR MOTOR AMMETER |
| EI 1055 | 201 | DOLOMITE SCREEN MOTOR AMMETER |
| EI 2121 | 203-1 | DEVOLATILIZER HEATER ELECTRIC INDICATOR |
| EI 2122 | 203-1 | DEVOLATILIZER HEATER ELECTRIC INDICATOR |
| EI 2123 | 203-1 | GASIFIER RECYCLE GAS 2 ELECTRICAL INDICATOR |
| EI 2124 | 203-1 | GASIFIER RECYCLE GAS 2 INLET ELECTRICAL INDICATOR |
| FCV 1006 | 202 | PROCESS AIR FLOW CONT VLV |
| FCV 1009 | 202 | QUENCHED FLUE GAS FLOW CONT VLV |
| FCV 2000 | 203-1 | DEVOLATILIZER CO2 FLOW CONTROL VALVE |
| FCV 2004 | 203-1 | CO2 GAS FLOW CONTROL VALVE |
| FCV 2013 | 204-1 | DOLOMITE LIFT GAS HTR AIR FLOW CONT VLV |
| FCV 2014 | 204-1 | RECYCLE FLUE GAS FLOW CONTROL VALVE |
| FCV 2028 | 208 | FIRST STAGE RECYCLE CO2 CMPR FUEL GAS INLT FLOW CONT VLV<br>STD VENDOR PKG |
| FCV 2028A | 208 | FIRST STAGE RECYCLE CO2 CMPR FUEL GAS INLT FLOW CONT VLV A<br>STD VENDOR PKG |
| FCV 2032 | 204-1 | RECYCLE FLUE GAS FLOW CONT VLV |
| FCV 2113 | 204-1 | AIR HEATER INLET AIR FLOW CONT VLV |
| FCV 2126 | 204-2 | RECYCLE GAS 2 FLOW CONT VALVE |
| FCV 3013 | 208 | HPC ABSORBER CARBONATE SOLUTION INLT FLOW CONT VLV<br>STD DEVICE |
| FCV 3014 | 208 | REBOILER STEAM INLT FLOW CONT VLV<br>STD DEVICE |
| FCV 3036 | 206 | QUENCH STRIPPER INLT FLOW CONT VLV |
| FCV 3037 | 207 | DV QUENCH SEPARATOR WST WTR OUTL FLOW CONT VLV<br>STD DEVICE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FE 1005 | 202 | PRHTR FURNACE FUEL GAS INLT FLOW ELMT |
| FE 1006 | 202 | AIR FLOW ELEMENT |
| FE 1007 | 202 | INERT GAS FLOW ELEMENT |
| FE 1009 | 202 | PREHEATER VENTURI VENT FLOW ELMT |
| FE 1025 | 201 | DRYER FURNACE FUEL GAS INLET FLOW ELEMENT |
| FE 2013 | 204-1 | DOLOMITE LIFT GAS HEATER AIR INLT FLOW ELMT |
| FE 2014 | 204-1 | RECYCLE FLUE GAS FLOW ELMT |
| FE 2015 | 204-1 | RECYCLE GAS CHAR LIFT FLOW ELMT |
| FE 2027 | 204-2 | DV CYCLE COMP RECYCLE GAS FLOW ELMT |
| FE 2029 | 202 | QUENCHED FLUE GAS FLOW ELMT |
| FE 2032 | 204-1 | RECYCLE FLUE GAS FLOW ELMT |
| FE 2113 | 204-1 | AIR HEATER INLET AIR FLOW ELMT |
| FE 2119 | 203-3 | DV STEAM DRUM VENT FLOW ELMT |
| FE 2120 | 203-3 | RG STEAM DRUM VENT FLOW ELMT |
| FE 2121 | 203-3 | GP CONDENSATE DRAIN FLOW ELMT |
| FE 3000 | 207 | WASTE GAS TO FLARE FLOW ELEM |
| FE 3000 A | 207 | WASTE GAS TO FLARE PRESS CONT VLV BY-PASS FLOW ELEM<br>STD DEVICE |
| FE 3013 | 208 | HPC ABSORBER CARBONATE SOLUTION INLT FLOW ELEM<br>STD DEVICE |
| FE 3014 | 208 | REBOILER STEAM INLT FLOW ELEM<br>STD DEVICE |
| FE 3029 | 208 | HPC ABSORBER QUENCHED FLUE GAS INLET FLOW ELEM<br>STD DEVICE |
| FE 3030 | 207 | QUENCHED GAS STRM 2 FLOW ELEM<br>STD REGARDLESS EXACT TYPE OF ELEMENT<br>GAS FLOW WELL DOCUMENTED |
| FE 3036 | 206 | QUENCH STRIPPER INLT FLOW ELEM |
| FE 3037 | 207 | DV QUENCH SEPARATOR WST WTR OUTL FLOW ELEM<br>STD DEVICE |
| FE 3038 | 208 | CO2 AFTERCOOLER OUTL FLOW IND<br>STD DEVICE |
| FE 3044 | 208 | FIRST STAGE RECYCLE CO2 CMPR FUEL GAS INLT FLOW ELEM<br>STD VENDOR PKG |
| FE 5046 | 204-1 | INERT GAS START-UP CHAR LIFT FLOW ELMT |
| FFM 1005 | 202 | N2/AIR FLOW RATIO AMPLIFIER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FHC 2028 | 208 | FIRST STAGE RECYCLE CO2 CMPR FUEL GAS INLT FCV A HAND CONT STD VENDOR PKG |
| FI 1011 | 203-2 | LIGNITE PREHEATER BED LEVEL D/P LINE PURGE FLOW IND |
| FI 1012 | 203-2 | LIGNITE PREHEATER BED LEVEL D/P LINE PURGE FLOW IND |
| FI 1013 | 203-2 | LIGNITE PREHEATER BED LEVEL D/P LINE PURGE FLOW IND |
| FI 1014 | 201 | LIGNITE SILO INERT GAS PURGE SUPPLY FLOW INDICATOR |
| FI 1015 | 202 | VENTURI SCRUBBER CW INLT FLOW IND |
| FI 1017 | 201 | WILLIAMS MILL INERT GAS INLET FLOW INDICATOR |
| FI 1019 | 201 | BAG HOUSE INERT GAS INLET FLOW INDICATOR |
| FI 1020 | 201 | LIGNITE FINES BIN INERT GAS INLET FLOW INDICATOR |
| FI 1021 | 203-2 | PREHEATER VENTURI LEVEL LINE PURGE FLOW INDICATOR |
| FI 1022 | 203-2 | PREHEATER VENTURI LEVEL LINE PURGE FLOW IND |
| FI 1025 | 201 | DRYER FURNACE FUEL GAS INLET FLOW INDICATOR |
| FI 1027 | 201 | DRY LIGNITE FEEDER VALVE 109 INERT GAS SPLY FLOW INDICATOR |
| FI 1028 | 203-2 | HOT LIGNITE FEEDER PURGE FLOW IND |
| FI 1031 | 201 | MILL SEPARATOR DSCH LINE EJ 101 INERT GAS INLT FLOW IND |
| FI 1032 | 201 | MILL SEPARATOR DSCH LINE EJ 100 INERT GAS INLT FLOW IND |
| FI 1033 | 201 | LIGNITE CYCLONE OUTLET INERT GAS SUPPLY FLOW INDICATOR |
| FI 1034 | 201 | DRY LIGNITE FEEDER VALVE 109A INERT GAS SPLY FLOW INDICATOR |
| FI 1039 | 202 | INERT GAS FLOW INDICATOR |
| FI 1041 | 201 | DRYER FURNACE COOLING WATER SUPPLY FLOW SIGHT GLASS |
| FI 2006 | 203-1 | DEVOLATILIZER LIGNITE LN RECYCLE GAS SUPPLY FLOW INDICATOR |
| FI 2007 | 203-1 | START UP LINE RECYCLE GAS 2 FLOW INDICATOR |
| FI 2030 | 203-1 | DOLOMITE OUT HOPPER DIFFERENTIAL LINE PURGE FLOW INDICATOR |
| FI 2033 | 203-1 | PURGE GAS B FLOW INDICATOR |
| FI 2033B | 203-2 | DEVOLATILIZER CYCLONE DSCH D/P LINE PURGE FLOW IND |
| FI 2035 | 203-2 | DEVOLATILIZER D/P LINE PURGE FLOW IND |
| FI 2036 | 203-2 | DEVOLATILIZER D/P LINE PURGE FLOW IND |
| FI 2038 | 203-2 | DEVOLATILIZER D/P LINE PURGE FLOW IND |
| FI 2041 | 203-2 | DEVOLATILIZER D/P LINE PURGE FLOW IND |
| FI 2042 | 203-2 | DEVOLATILIZER D/P LINE PURGE FLOW IND |
| FI 2045 | 203-1 | PURGE GAS B FLOW INDICATOR |
| FI 2045A | 203-2 | DEVOLATILIZER LEVEL D/P LINE PURGE FLOW IND |
| FI 2046 | 203-2 | CHAR LIFT LINE D/P TAP LINE PURGE FLOW IND |
| FI 2047 | 203-2 | DEVOLATILIZER SPENT CHAR D/P LINE PURGE FLOW IND |
| FI 2049 | 203-2 | DEVOLATILIZER DSCH D/P LINE PURGE FLOW IND |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SPC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FI 2052 | 203-2 | DOLOMITE HOPPER OUT D/P LINE PURGE FLOW IND |
| FI 2054 | 203-2 | DOLOMITE HOPPER OUT D/P LINE PURGE FLOW IND |
| FI 2055 | 203-1 | DOLOMITE VALVE PURGE GAS FLOW INDICATOR |
| FI 2055B | 203-2 | DOLOMITE HOPPER OUT D/P LINE PURGE FLOW IND |
| FI 2057 | 203-1 | DOLOMITE VALVE PURGE GAS FLOW INDICATOR |
| FI 2057B | 203-2 | DOLOMITE HOPPER OUT D/P LINE PURGE FLOW IND |
| FI 2060 | 203-2 | SPENT DOLOMITE LINE PURGE FLOW IND |
| FI 2066 | 203-2 | SPENT CHAR LINE PURGE GAS FLOW IND |
| FI 2068 | 203-2 | REGENERATOR/LIGNITE HOPPERS D/P LINE PURGE FLOW IND |
| FI 2068A | 203-2 | DOLOMITE DSCH LINE PURGE FLOW IND |
| FI 2069 | 203-2 | DOLOMITE LINE PURGE FLOW XMTIR |
| FI 2070 | 203-2 | REGENERATOR VENT HDR PURGE FLOW IND |
| FI 2072 | 203-2 | REGENERATOR PURGE LINE FLOW IND |
| FI 2074 | 203-2 | REGENERATOR D/P LINE PURGE FLOW IND |
| FI 2075 | 203-2 | SPENT CHAR LINE PURGE FLOW IND |
| FI 2076 | 203-2 | SPENT DOLOMITE LINE PURGE FLOW IND |
| FI 2077 | 203-2 | SPENT DOLOMITE LINE PURGE FLOW IND |
| FI 2078 | 203-2 | SPENT CHAR LINE PURGE FLOW IND |
| FI 2081 | 203-2 | ENGAGER POT TE LINE PURGE FLOW IND |
| FI 2082 | 203-2 | SPENT CHAR LIFT LINE D/P LINE PURGE FLOW IND |
| FI 2085 | 203-2 | GASIFIER SPENT DOLOMITE LINE PURGE FLOW IND |
| FI 2087A | 203-2 | DEVOLATILIZER/GASIFIER PURGE BY-PASS FLOW IND |
| FI 2089 | 203-2 | DOLOMIT LINE D/P TAP LINE PURGE FLOW INDICATOR |
| FI 2091 | 203-2 | DOLOMITE LINE D/P TAP LINE PURGE FLOW INDICATOR |
| FI 2092 | 203-2 | GASIFIER D/P LINE PURGE FLOW INDICATOR |
| FI 2094 | 203-2 | GASIFIER VAPOR SPACE TAP LINE PURGE FLOW IND |
| FI 2095 | 203-2 | GASIFIER D/P LINE PURGE FLOW INDICATOR |
| FI 2096 | 203-2 | GASIFIER D/P LINE PURGE FLOW INDICATOR |
| FI 2098 | 203-2 | GASIFIER D/P LINE PURGE FLOW IND |
| FI 2100 | 203-2 | GASIFIER D/P LINE PURGE FLOW IND |
| FI 2102 | 203-2 | GASIFIER D/P LINE PURGE FLOW IND |
| FI 2104 | 203-2 | GASIFIER D/P LINE PURGE FLOW IND |
| | | THESE ARE BOARD MTD ROTAMETERS |
| FI 2105 | 203-2 | GASIFIER SPENT CHAR LINE PURGE FLOW IND |
| FI 2106 | 203-2 | SPENT CHAR LINE PURGE FLOW IND |
| FI 2107 | 203-2 | GASIFIER SPENT DOLOMITE LINE PURGE FLOW IND |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEV I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FI 2112 | 203-2 | PURGE GAS FLOW |
| FI 2112A | 203-2 | DEVOLATILIZER BED LEVEL D/P LINE PURGE FLOW XMTR |
| FI 2116 | 203-2 | LIGNITE HOPPERS PURGE FLOW IND |
| FI 2117 | 203-2 | LIGNITE FEED LINES A/B FLOW IND |
| FI 2127 | 203-2 | LIGNITE HOPPER A PURGE LINE FLOW IND |
| FI 2127A | 203-2 | PURGE GAS FLOW IND |
| FI 2128 | 203-2 | DOLOMITE FEEDER FLOW INDICATOR |
| FI 2128A | 203-2 | PURGE GAS FLOW IND |
| FI 2137 | 203-1 | DV DUMP HOPPER VENT PURG GAS FLOW INDICATOR |
| FI 2138 | 203-1 | PURGE GAS B FLOW INDICATOR |
| FI 2144 | 202 | CO2 DRYER FLOW IND |
| FI 2147 | 204-1 | RECYCLE FLUE GAS DRYER FLOW IND |
| FI 2148 | 204-2 | RECYCLE GAS B DRYER REGEN FLOW IND |
| FI 2149 | 203-2 | GASIFIER CHAR DSCH D/P LINE PURGE FLOW IND |
| FI 2150 | 203-2 | DEVOLATILIZER TEMP ELMT LINE PURGE FLOW IND |
| FI 2151 | 203-2 | DEVOLATILIZER PRESS XMTR LINE PURGE FLOW IND |
| FI 2152 | 203-2 | GASIFIER FE LINE PURGE FLOW IND |
| FI 2153 | 203-2 | GASIFIER TE LINE PURGE FLOW IND |
| FI 2154 | 203-2 | GASIFIER PT LINE PURGE FLOW IND |
| FI 2155 | 203-2 | DEVOLATILIZER CYCLONE DSCH D/P LINE PURGE FLOW IND |
| FI 2156 | 203-2 | GASIFIER PT LINE PURGE FLOW IND |
| FI 2157 | 203-2 | DOLOMITE LINE D/P TAP LINE PURGE FLOW IND |
| FI 2158 | 203-1 | PURGE GAS B FLOW INDICATOR |
| FI 2158A | 203-2 | DEVOLATILIZER DOLOMITE INLET D/P LINE PURGE FLOW IND |
| FI 2159 | 203-2 | REGENERATOR D/P LINE PURGE FLOW IND |
| FI 2160 | 203-2 | DOLOMITE LINE TAP LINE PURGE FLOW IND |
| FI 2161 | 203-2 | DEVOLATILIZER BED LEVEL D/P LINE PURGE FLOW IND |
| FI 2162 | 203-2 | DEVOLATILIZER CHAR DSCH D/P LINE PURGE FLOW IND |
| FI 2163 | 203-2 | SPENT CHAR LINE PURGE GAS FLOW IND |
| FI 2164 | 203-2 | GASIFIER SPENT DOLOMITE LINE PURGE FLOW IND |
| FI 2165 | 203-2 | DEVOLATILIZER SPENT CHAR D/P LINE PURGE FLOW IND |
| FI 2166 | 203-2 | SPENT DOLOMITE LINE PURGE GAS FLOW IND |
| FI 2167 | 203-2 | GASIFIER LIGNITE LINE PURGE GAS FLOW IND |
| FI 2168 | 203-2 | GASIFIER SPENT CHAR LINE PURGE FLOW IND |
| FI 2169 | 203-2 | SPENT CHAR LINE PURGE GAS FLOW IND |
| FI 2170 | 203-2 | SPENT CHAR LINE PURGE FLOW IND |

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FI 2171 | 203-2 | GASIFIER WASTE DOLOMITE LINE PURGE FLOW IND |
| FI 2172 | 203-2 | SPENT DOLOMITE LINE PURGE FLOW IND |
| FI 2173 | 203-2 | SPENT DOLOMITE LINE PURGE FLOW IND |
| FI 2174 | 203-2 | SPENT DOLOMITE LINE PURGE GAS FLOW IND |
| FI 2176 | 203-2 | PROCESS GAS 2 FLOW INDICATOR |
| FI 2177 | 203-2 | PRODUCT GAS LINE 2 FLOW INDICATOR |
| FI 2178 | 203-2 | DEVOLATILIZER CHAR DSCH D/P LINE PURGE FLOW IND |
| FI 2179 | 203-2 | DEVOLATILIZER CHAR DSCH D/P LINE PURGE FLOW IND |
| FI 2180 | 203-2 | DEVOLATILIZER CHAR DSCH D/P LINE PURGE FLOW IND |
| FI 2181 | 203-2 | GASIFIER SPENT CHAR DSCH LINE PURGE FLOW IND |
| FI 2182 | 203-2 | SPENT CHAR LINE PURGE GAS FLOW IND |
| FI 2183 | 203-2 | GASIFIER LIGNITE LINE PURGE GAS FLOW IND |
| FI 2188 | 203-1 | PURGE GAS B FLOW INDICATOR |
| FI 2188A | 203-2 | DEVOLATILIZER DUMP D/P LINE FLOW IND |
| FI 2189 | 203-2 | GASIFIER/REGENERATOR SPENT CHAR LINE PURGE FLOW IND |
| FI 2212 | 203-2 | DOLOMITE OUT HOPPER D/P LINE PURGE FLOW IND |
| FI 2213 | 203-2 | GASIFIER D/P LINE PURGE FLOW INDICATOR |
| FI 2214 | 205 | ASH OUT HOPPER A OUTL PURGE GAS FLOW IND |
| FI 2215 | 205 | ASH OUT HOPPER B OUTL PURGE GAS FLOW IND |
| FI 2216 | 202 | PURGE BLEED FL IND |
| FI 2265 | 205 | ASH OUT HOPPER A/B OUTL INERT GAS PURGE FLOW IND |
| FI 2272 | 205 | ASH OUT HOPPER A RELIEF VENT GAS FLOW IND |
| FI 2273 | 205 | ASH OUT HOPPER B RELIEF VENT GAS FLOW IND |
| FI 2274 | 203-1 | REGENERATOR DIFFERENTIAL LINE PURGE FLOW INDICATOR |
| FI 2275 | 203-1 | REGENERATOR DIFFERENTIAL LINE PURGE FLOW INDICATOR |
| FI 2276 | 203-1 | REGENERATOR DIFFERENTIAL LINE PURGE FLOW INDICATOR |
| FI 2277 | 203-1 | REGENERATOR DIFFERENTIAL LINE PURGE FLOW INDICATOR |
| FI 2278 | 203-1 | REGENERATOR DIFFERENTIAL LINE PURGE FLOW INDICATOR |
| FI 2279 | 203-1 | REGENERATOR DIFFERENTIAL LINE PURGE FLOW INDICATOR |
| FI 2281 | 203-1 | RECYCLE GAS STREAM 2 FLOW INDICATOR |
| FI 3018 | 208 | HPC CIRC PUMP DSCH FLOW IND<br>STD DEVICE |
| FI 3023 | 205 | RG QUENCH COOLER OUTL FLOW IND |
| FI 3024 | 206 | GF QUENCHER QUENCH WTR INLT FLOW IND |
| FI 3028 | 207 | DV QUENCHER QUENCH WTR INLT FLOW IND<br>PROCESS WATER-NO PROBLEM |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FI 3029 | 208 | HPC ABSORBER QUENCHED FLUE GAS INLET FLOW IND<br>STD DEVICE |
| FI 3032 | 206 | GF VENTURI QUENCH WTR INLT FLOW IND |
| FI 3033 | 207 | DV VENTURI QUENCH WTR INLT FLOW IND<br>PROCESS WTR-NO PROBLEM |
| FI 3034 | 208 | SO2 SCRUBBER WST WTR INLT FLOW IND<br>STD DEVICE |
| FI 3038C | 208 | CO2 AFTER COOLER OUTL FLOW IND |
| FI 3039 | 202 | CO2 LIGNITE HOPPER DSCH VLV PURGE FLOW IND |
| FI 3040 | 202 | PRG GAS FLOW IND |
| FI 3041 | 203-1 | RECYCLE FLUE GAS IN-LINE FLOW INDICATOR |
| FI 3042 | 206 | QUENCH STRIPPER BLR FEED WTR INLT FLOW IND |
| FI 3043 | 205 | RG QUENCHER QUENCH WTR INLT FLOW IND |
| FI 5031 | 204-2 | RECYCLE GAS 2 FLOW INDICATOR |
| FIC 2028 | 208 | FIRST STAGE RECYCLE CO2 CMPR FUEL GAS INLT FLOW IND CONT<br>STD VENDOR PKG |
| FIC 2126 | 204-2 | RECYCLE GAS 2 IND FLOW CONT |
| FIC 3030 | 207 | QUENCHED GAS STRM 2 FLOW IND CONT<br>FLOWS ARE PROBABLY STABLE-NO PROBLEM<br>D/P CONTROL GENERALLY WELL DESIGNED |
| FIC 3036 | 206 | QUENCH STRIPPER INLT FLOW IND CONT |
| FIC 3037 | 207 | DV QUENCH SEPARATOR WST WTR OUTL FLOW IND CONT<br>STD DEVICE |
| FR 1005 | 202 | N2 FLOW RCDR |
| FR 1007 | 202 | INERT GAS FLOW RCDR |
| FR 2015 | 204-1 | RECYCLE GAS CHAR LIFT FLOW RCDR |
| FR 2027 | 204-2 | DV CYCLE COMP DSCH FLOW RCDR |
| FR 2029 | 202 | QUENCHED FLUE GAS FLOW RCDR |
| FR 2119 | 203-3 | DV JACKET STEAM OUTL FLOW RCDR |
| FR 2120 | 203-3 | RG STEAM DRUM VENT FLOW RECORDER |
| FR 2121 | 203-3 | GF JACKET STEAM OUTL FLOW RCDR |
| FR 2130 | 203-1 | SPENT DOLOMITE LINE VALVE PURGE GAS FLOW RECORDER |
| FR 2131 | 203-1 | SPENT DOLOMITE LINE PURGE GAS SUPPLY FLOW RECORDER |
| FR 2132 | 203-1 | RECYCLE FLUE GAS FLOW RECORDER |
| FR 2133 | 203-1 | RECYCLE FLUE GAS TO DOLOMITE LINE FLOW RECORDER |
| FR 2135 | 203-1 | PURGE GAS FOR SPENT DOLOMITE VALVE FLOW RECORDER |

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FR 3000 | 207 | WASTE GAS TO FLARE FLOW REC<br>STD DEVICE |
| FR 5046 | 204-1 | INERT GAS START-UP CHAR LIFT FLOW RCDR |
| FRC 1006 | 202 | AIR FLOW RECORDING CONTROLLER |
| FRC 1009 | 202 | PREHEATER VENTURI VENT FLOW RCDR CONT |
| FRC 2000 | 203-1 | DEVOLATILIZER CO2 SUPPLY FLOW RECORDING CONTROLLER |
| FRC 2004 | 203-1 | CO2 GAS RECORDING FLOW CONTROL |
| FRC 2013 | 204-1 | DOLOMITE LIFT GAS HTR AIR FLOW REC CONT |
| FRC 2014 | 204-1 | RECYCLE FLUE GAS FLOW REC CONTROL |
| FRC 2032 | 204-1 | RECYCLE FLUE GAS FLOW REC CONT |
| FRC 2113 | 204-1 | AIR HEATER INLET AIR FLOW REC CONTROL |
| FRC 3013 | 208 | HPC ABSORBER CARBONATE SOLUTION INLT FLOW REC CONT<br>STD DEVICE |
| FRC 3014 | 208 | REBOILER STEAM INLT FLOW REC CONT<br>STD DEVICE |
| FSH 2120 | 203-3 | RG STEAM DRUM VENT FLOW SW HI |
| FSH 2121 | 203-3 | GF STEAM CONDENSATE FLOW SW HI |
| FSL 1039 | 201 | DRYER FURNACE COOLING WATER SUPPLY FLOW SWITCH LOW<br>TIE IN TO ALARM OR ANNUNCIATOR NOT SHOWN |
| FSL 2008 | 204-1 | AIR HEATER INLET LOW FLOW SW |
| FSL 2009 | 204-1 | DOLOMITE LIFT HTR LIFT GAS INLT FLOW SW LO |
| FSL 2016 | 204-1 | CHAR LIFT HEATER RECYCLE FLUE GAS LO FLOW SW |
| FSL 2122 | 203-3 | DV JACKET WTR FLOW SW LO |
| FSL 2123 | 203-3 | RG JACKET WATER CIRC PUMP DSCH FLOW SW LO |
| FSL 2124 | 203-3 | GASIFIER JACKET WTR CIRC PUMPS DSCH FLOW SW LO |
| FSL 3015 | 206 | GF QUENCHER QUENCH WTR INLT LO FLOW SW |
| FSL 3016 | 205 | RG QUENCH COOLER OUTL LOW FLOW SWITCH |
| FSL 3017 | 207 | DV QUENCHER QUENCH WTR INLT LO FLOW SW<br>NO PROBLEM |
| FT 1005 | 202 | PRHTR FURNACE FUEL GAS FLOW XMTR |
| FT 1006 | 202 | AIR FLOW TRANSMITTER |
| FT 1007 | 202 | INERT GAS FLOW TRANSMITTER |
| FT 1009 | 202 | PREHEATER VENTURI VENT FLOW XMTR |
| FT 2000 | 203-1 | DEVOLATILIZER CO2 SUPPLY FLOW TRANSMITTER |
| FT 2004 | 203-1 | CO2 GAS FLOW TRANSMITTER |
| FT 2013 | 204-1 | DOLOMITE LIFT GAS HTR AIR INLT FLOW XMTR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FT 2014 | 204-1 | RECYCLE FLUE GAS FLOW XMTR |
| FT 2015 | 204-1 | RECYCLE GAS CHAR LIFT FLOW XMTR |
| FT 2027 | 204-2 | DV CYCLE COMP RECYCLE GAS FLOW XMTR |
| FT 2028 | 208 | FIRST STAGE RECYCLE CO2 CMPR FUEL GAS INLT FLOW XMTR<br>STD VENDOR PKG |
| FT 2029 | 202 | QUENCHED FLUE GAS FLOW XMTR |
| FT 2032 | 204-1 | RECYCLE FLUE GAS FLOW XMTR |
| FT 2113 A | 204-1 | AIR HEATER AIR INLET FLOW XMTR |
| FT 2113 B | 204-1 | AIR HEATER INLET AIR FLOW XMTR |
| FT 2119 | 203-3 | DV STEAM DRUM VENT FLOW XMTR |
| FT 2120 | 203-3 | RG STEAM DRUM VENT FLOW XMTR |
| FT 2121C | 203-3 | GF CONDENSATE DRAIN FLOW XMTR |
| FT 2126 | 204-2 | RECYCLE GAS 2 FLOW XMTR |
| FT 2130 | 203-1 | SPENT DOLOMITE LINE VALVE PURGE GAS FLOW TRANSMITTER |
| FT 2131 | 203-1 | SPENT DOLOMITE VALVE PURGE GAS SUPPLY FLOW TRANSMITTER |
| FT 2132 | 203-1 | RECYCLE FLUE GAS IN-LINE FLOW TRANSMITTER |
| FT 2133 | 203-1 | RECYLE FLUE GAS TO DOLOMITE LINE IN-LINE FLOW XMTR |
| FT 2135 | 203-1 | PURGE GAS FOR SPENT DOLOMITE VALVE FLOW TRANSMITTER |
| FT 3000 | 207 | WASTE GAS TO FLARE FLOW XMTR<br>STD XMTRS OK |
| FT 3000 A | 207 | WASTE GAS TO FLARE PRESS CONT VLV BY-PASS FLOW XMTR<br>STD DEVICE |
| FT 3013 | 208 | HPC ABSORBER CARBONATE SOLUTION INLT FLOW XMTR<br>STD DEVICE |
| FT 5046 | 204-1 | INERT GAS START-UP CHAR LIFT FLOW TRANSMITTER |
| KC 2102 | 202 | CO2 DRYER CONTROL TIMER |
| KC 2109 | 204-1 | RECYCLE FLUE GAS DRYER REGEN TIMER CONT |
| KC 2112 | 204-2 | B GAS DRYER CYCLE TIMING VALVE |
| KC 2149 | 203-1 | DOLOMITE SUPPLY VALVE CONTROL TIMER |
| KC 2149A | 203-1 | DOLOMITE SUPPLY VALVE CONTROL TIMER |
| KC 2149B | 203-1 | SPENT CHAR LIFT LINE D/P TIMING CONTROL |
| KC 2149C | 203-1 | SPENT DOLOMITE LEVEL CONTROL TIMER |
| KSV 2107 | 204-1 | RECYCLE FLUE GAS DRYER CYCLE TIMER SOL VLV |
| KSV 2108 | 204-1 | RECYCLE FLUE GAS DRYER REGEN TIMING SOL VLV |
| KSV 2110 | 204-2 | RECYCLE GAS DRYER CYCLE TIMING VALVE |
| KSV 2111 | 204-2 | RECYCLE GAS FILTER/DRYER CYCLE TIMING VLV |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LC 2011 | 203-3 | DV STEAM DRUM LEVEL CONTROL |
| LC 2013 | 203-3 | RG STEAM DRUM LEVEL CONT |
| LC 2015 | 203-3 | GF STEAM DRUM LEVEL CONT |
| LC 3002 | 205 | RG QUENCHER QUENCH WTR LVL CONTROLLER |
| LC 3044 | 208 | SO2 SCRUBBER LEVEL CONTROLLER<br>STD DEVICE |
| LC 3046 | 208 | HPC ABSORBER LEVEL CONTROLLER<br>STD DEVICE |
| LC 3048 | 208 | CO2 KO POT LVL CONTROLLER<br>STD DEVICE |
| LC 3079 | 206 | QUENCH STRIPPER LEVEL CONTROLLER |
| LCV 1016 | 202 | PREHTR VENTURI LVL CONT VLV |
| LCV 2000 | 203-1 | DOLOMITE DUMP HOPPER LEVEL CONTROL VALVE |
| LCV 2001 | 203-1 | DEVOLATILIZER SPENT DOLOMITE DSCH LEVEL CONTROL VALVE |
| LCV 2002 | 203-1 | COKE DISCHARGE LINE LEVEL CONTROL VALVE |
| LCV 2002A | 203-2 | GASIFIER SPENT CHAR LEVEL CONTROL VALVE |
| LCV 2003 | 203-1 | SPENT DOLOMITE LINE LEVEL CONTROL VALVE |
| LCV 2011 | 203-3 | DV STEAM DRUM LEVEL CONT VLV |
| LCV 2013 | 203-3 | RG STEAM DRUM LEVEL CONT VLV |
| LCV 2015 | 203-3 | GF STEAM DRUM FEEDWATER INLT LEVEL CONT VLV |
| LCV 3002 | 205 | RG QUENCHER QUENCH WTR LVL CONT VLV |
| LCV 3010 | 206 | GF QUENCH SEPARATOR WASTE OIL LVL CONT VLV |
| LCV 3012 | 206 | GF QUENCH SEPARATOR LVL CONT VLV |
| LCV 3027 | 207 | DV QUENCH SEPARATOR LVL CONT VLV<br>STD APPLICATION OK |
| LCV 3035 | 207 | DV QUENCH SEPARATOR LVL CONT VLV<br>STD DEVICE |
| LCV 3044 | 208 | SO2 SCRUBBER LEVEL CONT VLV<br>STD DEVICE-STD APPLICATION |
| LCV 3046 | 208 | HPC ABSORBER LEVEL CONT VLV<br>STD DEVICE |
| LCV 3048 | 208 | CO2 KO POT LVL CONT VLV<br>STD DEVICE |
| LCV 3078 | 206 | GF VENTURI LEVEL CONT VLV |
| LCV 3079 | 206 | QUENCH STRIPPER LEVEL CONTROL VALVE |
| LG 1015 | 202 | PREHEATER VENTURI LVL GLASS |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LG 2010 | 203-3 | DV STEAM DRUM LEVEL GLASS |
| LG 2012H | 203-3 | RG STEAM DRUM LEVEL GLASS HIGH |
| LG 2012L | 203-3 | RG STEAM DRUM LEVEL GLASS LO |
| LG 2014 | 203-3 | GF STEAM DRUM LEVEL GLASS |
| LG 2032 | 203-3 | GF CONDENSATE DRAIN LEVEL GLASS |
| LG 3003 | 205 | RG QUENCHER QUENCH WTR LVL GLASS |
| LG 3011 | 206 | GF QUENCH SEPARATOR WASTE OIL LEVEL GLASS |
| LG 3013 | 206 | GF QUENCH SEPARATOR LVL GLASS |
| LG 3028 | 207 | DV QUENCH SEPARATOR LVL GLASS<br>STD DEVICE |
| LG 3036 | 207 | DV QUENCH SEPARATOR LVL GLASS<br>STD DEVICE |
| LG 3043 | 208 | SO2 SCRUBBER LEVEL GLASS<br>STD DEVICE |
| LG 3045 | 208 | HPC ABSORBER LEVEL GLASS<br>STD DEVICE |
| LG 3047 | 208 | CO2 KO POT LVL GLASS<br>STD DEVICE |
| LG 3060 | 208 | HPC STRIPPER LEVEL GLASS<br>STD DEVICE |
| LG 3065 | 206 | SLOP TANK LEVEL GLASS |
| LG 3074 | 208 | HPC INHIBITOR FEED SPLY TNK LEVEL GLASS<br>STD DEVICE |
| LG 3075 | 208 | ANTI-FOAM FEEDER SPLY TNK LVL GLASS<br>STD DEVICE |
| LG 3080 | 206 | QUENCH STRIPPER LEVEL GLASS |
| LG 5029 | 205 | QUENCH INHIBITOR FEEDER LVL GLASS |
| LHC 2000 | 203-1 | DOLOMITE POT LEVEL HAND CONTROL |
| LI 1009 | 201 | LIGNITE SILO LEVEL INDICATOR |
| LIC 1016 | 202 | PREHEATER VENTURI LVL IND CONT |
| LIC 2001 | 203-1 | DEVOLATILIZER DOLOMITE POT LEVEL INDICATING CONTROL |
| LIC 2002 | 203-1 | SPENT CHAR LINE INDICATING LEVEL CONTROL |
| LIC 2003 | 203-1 | GASIFIER SPENT DOLOMITE BED INDICATING LEVEL CONTROL |
| LS 3072 | 207 | DV QUENCH SEPARATOR LVL SW<br>STD DEVICE |
| LS 3087 | 205 | RG QUENCHER QUENCH WTR LVL SW |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE $CO_2$ ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LSH 1017 | 202 | PREHEATER VENTURI LVL SW HI |
| LSH 1019 | 201 | BELT FEEDER PIT SUMP PUMP LEVEL SWITCH HIGH |
| | | PROBABLY A STANDARD PACKAGE -- STARTS PUMP |
| LSH 2005 | 205 | RG CYCLONE LVL SW HI |
| LSH 2018 | 203-3 | DV STEAM DRUM LEVEL SWITCH LO |
| LSH 2021 | 203-3 | GF CONDENSATE DRAIN TANK LEVEL SW HI |
| LSH 2023 | 203-3 | RG STEAM DRUM LEVEL SW HIGH |
| LSH 3008 | 207 | DV QUENCH SEPARATOR HI LVL SW |
| | | STD DEVICE |
| LSH 3051 | 206 | GF QUENCH SEPARATOR HI LVL SW |
| LSH 3054 | 206 | GF KO POT HI LVL SW |
| LSH 3056 | 207 | DV KO POT HI LVL SW |
| | | THIS TYPE OF LEVEL GENERALY OK |
| LSH 3060 | 208 | RG KO POT HI LVL SW |
| | | STD DEVICE |
| LSH 3066 | 206 | SLOP TANK HI LEVEL SW |
| LSH 3070 | 208 | HPC STRIPPER HI LVL SW |
| | | STD DEVICE |
| LSH 3083 | 208 | $CO_2$ KO POT HI LVL SW |
| | | STD DEVICE |
| LSH 3086B | 205 | RG QUENCHER QUENCH WTR HI LVL SW |
| LSL 2019 | 203-3 | DV STEAM DRUM LEVEL SWITCH LO |
| LSL 2020 | 203-3 | RG STEAM DRUM LEVEL SW LO |
| LSL 2022 | 203-3 | GF CONDENSATE DRAIN TANK LEVEL SW LO |
| LSL 2028 | 203-1 | DOLOMITE LEVEL SWITCH LOW |
| LSL 3052A | 206 | GF QUENCH SEPARATOR LO LVL SW |
| | | STD DEVICE |
| LSL 3052B | 207 | DV QUENCH SEPARATOR LO LVL SW |
| LSL 3071 | 206 | GF QUENCH SEPARATOR WASTE OIL LO LVL SW |
| LSL 3077 | 208 | HPC STRIPPER LO LVL SW |
| | | STD DEVICE |
| LSL 3081 | 206 | QUENCH STRIPPER LO LEVEL SW |
| LSL 3087 | 207 | DV QUENCH SEPARATOR LO LVL SW |
| | | STD DEVICE |
| LT 1016 | 202 | PREHEATER VENTURI LEVEL XMTR |
| LT 2003A | 203-2 | GASIFIER LEVEL XMTR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PC 3072 | 206 | QUENCH STRIPPER WASTE GAS OUTL PRESS CONT |
| PCV 1000 | 201 | DRYER FURNACE VENT PRESSURE CONTROL VALVE<br>INTERLOCKED WITH WILLIAMS MILL DISCHARGE PRESSURE |
| PCV 1010 | 202 | INERT GAS PRESS CONT VLV |
| PCV 1012 | 202 | ROOTS AIR COMPRESSOR DSCH TO VENT HDR PRESS CONT VLV |
| PCV 1013 | 201 | WILLIAMS MILL INERT GAS INLET PRESSURE CONTROL VALVE |
| PCV 1014 | 201 | DRYER FURNACE FUEL GAS INLET PRESSURE CONTROL VALVE |
| PCV 1025 | 201 | DRYER FURNACE PILOT GAS PRESSURE CONTROL VALVE |
| PCV 1029 | 201 | DRYER FURNACE PILOT GAS INTERLOCK TO FUEL GAS PRESS CONT VLV |
| PCV 1034 | 202 | INERT GAS PRESS CONT VLV |
| PCV 1035 | 201 | DRY LIGNITE FEEDER INERT GAS INLET PRESSURE CONTROL VALVE |
| PCV 1041 | 201 | DRY LIGNITE FEEDER A INERT GAS SUPPLY PRESSURE CONTROL VALVE |
| PCV 1046 | 201 | DRYER FURNACE COOLING WATER SUPPLY PRESSURE CONTROL VALVE |
| PCV 2022 | 207 | QUENCHED GAS STRM 2 PRESS CONT VLV<br>STD CONT VLVS OK |
| PCV 2036 | 204-1 | AIR SURGE TANK PRESS CONT VLV |
| PCV 2037 | 204-1 | AIR HEATER STACK PRESS CONT VLV |
| PCV 2038 | 204-1 | DOLOMITE LIFT HEATER STACK PRESS CONT VLV |
| PCV 2040 | 204-1 | CHAR LIFT HEATER STACK PRESS CONT VLV |
| PCV 2041A | 204-1 | RECYCLE GAS PRESS CONT VALVE A |
| PCV 2041B | 204-1 | RECYCLE GAS PRESS CONT VALVE B |
| PCV 2052 | 204-2 | RECYCLE GAS 2 PRESS CONT VLV |
| PCV 2053 | 204-2 | DV CYCLE COMP DSCH PRESS CONT VLV |
| PCV 2071 | 202 | QUENCHED FLUE GAS PRESS CONT VLV |
| PCV 2071A | 202 | QUENCHED FLUE GAS PRESS CONT VLV |
| PCV 2113 | 204-1 | RECYCLE FLUE GAS PRESS CONT VLV |
| PCV 2159 | 202 | ALT INERT GAS SPLY PRESS CONT VLV |
| PCV 2194 | 204-1 | INSTRUMENT AIR HEADER PRESS CONT VLV |
| PCV 2205 | 208 | HPC STRIPPER CO2 INLT PRESS CONT VLV<br>STD DEVICE |
| PCV 2206 | 208 | HPC STRIPPER CO2 INLT PRESS CONT VLV<br>STD DEVICE |
| PCV 3009 | 207 | WASTE GAS TO FLARE PRESS CONT VLV<br>STD DEVICE OK |
| PCV 3009A | 207 | WASTE GAS TO FLARE PRESS CONT VLV A<br>STD DEVICE OK |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PCV 3051A | 208 | CO2 KO POT OUTL VENT PRESS CONT VLV<br>STD DEVICE |
| PCV 3051B | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR SUCT PRESS CONT VLV<br>STD DEVICE |
| PCV 3063 | 208 | RECYCLE CO2 PRESS CONT VLV<br>STD DEVICE |
| PCV 3072 | 206 | QUENCH STRIPPER WASTE GAS OUTL PRESS CONT VLV |
| PCV 5080 | 208 | FIRST STAGE RECYCLE CO2 CMPR INERT GAS INLT PRESS CONT VLV<br>STD DEVICE |
| PHS 3009 | 207 | WASTE GAS TO FLARE PRESS CONT VLV PRESS HAND SW<br>PS GENERALLY RELIABLE |
| PI 1001 | 201 | SECONDARY FAN SUCTION PRESSURE INDICATOR |
| PI 1003 | 201 | MAIN FAN DISCHARGE PRESSURE INDICATOR |
| PI 1004 | 201 | LIGNITE CYCLONE VENT GAS PRESSURE INDICATOR |
| PI 1005 | 201 | LIGNITE CYCLONE INLET PRESSURE INDICATOR |
| PI 1005-U | 207 | 5 UNLISTED PRESSURE IND<br>STD DEVICES |
| PI 1007 | 201 | AIR FAN DISCHARGE PRESSURE INDICATOR |
| PI 1007U | 206 | 7 UNLISTED PRESS IND<br>STD UNITS-NO CONTROL<br>BOURDON TUBE LINKED TO POINTER |
| PI 1008U | 203-3 | 8 UNLISTED PRESSURE INDICATORS<br>STANDARD UNITS-NO CONTROL<br>BOURDON TUBE LINKED TO POINTER |
| PI 1010U | 205 | 10 UNLISTED PRESS IND<br>STD UNITS-NO CONTROL<br>BOURDON TUBE LINKED TO POINTER |
| PI 1013 | 201 | WILLIAMS MILL INERT GAS INLET PRESSURE INDICATOR |
| PI 1013U | 203-2 | 13 PRESS IND UNLISTED<br>STD DEVICES NO CONTROL<br>BOURDON TUBE LINKED TO POINTER |
| PI 1016U | 204-1 | 16 UNLISTED PRESS IND<br>STD UNITS VERY RELIABLE-NO CONTROL<br>BOURDON OR DIAPHRAGM LINKED TO POINTER |
| PI 1017U | 202 | 17 UNLISTED PRESS IND<br>STANDARD ITEMS NO CONTROL<br>BOURDON TUBE MECH LINKED TO POINTER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PI 1018 | 201 | DRYER FURNACE FUEL GAS PRESSURE INDICATOR |
| PI 1019U | 208 | 19 UNLISTED PRESS IND STD DEVICES |
| PI 1020 | 201 | SECONDARY FAN DISCHARGE PRESSURE INDICATOR |
| PI 1023 | 201 | DRYER FURNACE PILOT GAS PRESSURE INDICATOR |
| PI 1028 | 201 | DRYER FURNACE PURGE AIR PRESSURE INDICATOR |
| PI 1050 | 201 | DRYER FURNACE COOLING WATER INLET PRESSURE INDICATOR |
| PI 2003 | 203-1 | DEVOLATILIZER RECYCLE GAS SUPPLY PRESSURE INDICATOR |
| PI 2004 | 203-1 | RECYCLE GAS INLET PRESSURE INDICATOR |
| PI 2005 | 203-1 | SPENT DOLOMITE LINE PRESSURE INDICATOR |
| PI 2006 | 203-1 | DEVOLATILIZER RECYCLE GAS INLET PRESSURE INDICATOR |
| PI 2008 | 203-1 | DUMP HOPPER VENT PRESSURE INLET |
| PI 2010 | 203-1 | DOLOMITE LIN PRESSURE INDICATOR |
| PI 2012 | 203-1 | DOLOMITE OUT HOPPER DSCH PRESSURE INDICATOR |
| PI 2017 | 203-1 | REGENERATOR AIR INLET PRESSURE INDICATOR |
| PI 2019 | 203-1 | SPENT DOLOMITE DSCH LINE PRESSURE INDICATOR |
| PI 2020 | 203-1 | SPENT CHAR DSCH LINE PRESSURE INDICATOR |
| PI 2021 | 203-1 | DOLOMITE SUPPLY PRESSURE INDICATOR |
| PI 2026 | 203-1 | GASIFIER COKE DSCH LINE PRESSURE INDICATOR |
| PI 2027 | 203-1 | GASIFIER SPENT DOLOMITE LINE PRESSURE INDICATOR |
| PI 2028 | 203-1 | SPENT CHAR LIFT GAS PRESSURE INDICATOR |
| PI 2031 | 203-1 | DOLOMITE OUT HOPPER RECYCLE GAS INLET PRESS IND |
| PI 2034 | 203-1 | PURGE GAS B PRESSURE INDICATOR |
| PI 2035 | 203-1 | SPENT DOLOMITE LIFT GAS PRESSURE INDICATOR |
| PIC 1012 | 202 | AIR VENT IND PRESS CONT |
| PIC 2036 | 204-1 | AIR SURGE TANK IND PRESS CONT |
| PIC 2037 | 204-1 | AIR HEATER STACK IND PRESS CONT |
| PIC 2038 | 204-1 | DOLOMITE LIFT HEATER STACK PRESS IND CONT |
| PIC 2040 | 204-1 | CHAR LIFT HEATER STACK PRESS IND CONT |
| PIC 3051 | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR SUCT PRESS IND CONTROLLER STD DEVICE |
| PIC 3063 | 208 | RECYCLE CO2 PRESS IND CONT STD DEVICE |
| PR 2001 | 203-1 | DEVOLATILIZER PROCESS GAS DSCH PRESSURE RECORDER |
| PR 2002 | 203-1 | DEVOLATILIZER DOLOMITE POT PRESSURE RECORDER |
| PR 2007 | 203-1 | RECYCLE GAS PRESSURE RECORDER |

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PR 2011 | 203-1 | DOLOMITE OUT HOPPER DSCH PRESSURE RECORDER |
| PR 2018 | 203-1 | DOLOMITE DSCH PRESSURE RECORDER |
| PR 2025 | 203-1 | GASIFIER SPENT DOLOMITE POT PRESSURE RECORDER |
| PR 2054 | 204-2 | DV CYCLE COMP DSCH PRESS RCDR |
| PR 2055 | 204-2 | QUENCHED FLUE GAS PRESS RCDR |
| PR 2064 | 202 | INERT GAS PRESS RCDR |
| PR 2065 | 202 | INERT GAS PRESS RCDR |
| PR 2098 | 203-1 | ENGAGER POT PRESSURECORDER |
| PR 2123 | 203-1 | ENGAGER POT PRESSURE RECORDER |
| PR 2224 | 205 | ASH OUT HOPPER A RELIEF VENT GAS PRESS REC |
| PR 2225 | 205 | ASH OUT HOPPER B RELIEF VENT GAS PRESS REC |
| PR 3016 | 208 | ABSORBER CONDENSER OUTL PRESS REC<br>STD DEVICE |
| PR 3020 | 205 | RG CYCLONE FLUE GAS OUTL PRESS REC |
| PRC 1000 | 201 | WILLIAMS MILL DSCH PRESSURE RECORDING CONTROLLER |
| PRC 1010 | 202 | INERT GAS PRESS RECORDING CONTROLLER |
| PRC 2022 | 203-1 | PROCESS GAS 2 PRESSURE RECORDING CONTROLLER |
| PRC 2041 | 204-1 | RECYCLE GAS PRESS REC CONT |
| PRC 2052 | 204-2 | DV CYCLE COMP DSCH PRESS REC CONT |
| PRC 2053 | 204-2 | DV CYCLE COMP DSCH REC PRESS CONT |
| PRC 2071 | 202 | QUENCHED FUEL GAS PRESS RECORDING CONT |
| PRC 2113 | 204-1 | RECYCLE FLUE GAS REC CONT |
| PRC 3000 | 207 | WASTE GAS TO FLARE PRESS REC CONT<br>STD DEVICE |
| PSH 1021 | 201 | DRYER FURNACE FUEL GAS INLET PRESSURE SWITCH HIGH |
| PSH 1032 | 202 | PRHTR FURNACE FUEL GAS HI PRESS SW |
| PSH 2030 | 204-2 | RECYCLE GAS 2 FILTER PRESS SW HI<br>NO ANNUNC SHOWN |
| PSH 2081 | 204-1 | RECYCLE FUEL GAS COMP DSCH PRESS SW HI<br>NO TIE TO ANNUNC SHOWN |
| PSHL 2022 | 203-1 | PROCESS GAS PRESSURE CONTROLLER HIGH/LOW |
| PSL 1022 | 201 | DRYER FURNACE FUEL GAS INLET PRESSURE SWITCH LOW |
| PSL 1024 | 201 | AIR FAN DISCHARGE PRESSURE SWITCH LOW |
| PSL 1031 | 202 | PRHTR FURNACE FUEL GAS LO PR SW |
| PSL 1056 | 202 | PROCESS AIR LO PRESS SW |
| PSL 2011 | 203-1 | DOLOMITE OUT HOPPER DSCH PRESSURE SWITCH LOW |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PSL 2080 | 202 | CO2 PRESS SW LO |
| PSL 2105 | 204-2 | QUENCHED FLUE GAS PRESS SW LO |
| PSL 2106 | 204-2 | QUENCHED GAS LINE PRESS SW LO |
| PSL 2114 | 204-1 | RECYCLE GAS PRESS SW LO |
| PSL 2143 | 203-3 | DV STEAM DRUM PRESS SW LO |
| PSL 2144 | 203-3 | GP STEAM DRUM PRESS SW LO |
| PSL 2165 | 204-1 | MAIN AIR COMPRESSOR LUBE OIL PRESS SW LO |
| PSL 3034 | 206 | QUENCH STRIPPER PMPS DISCH HDR LO PRESS SW |
| PSL 3038 | 207 | DV QUENCH PMPS DISCH HDR LO PRESS SW<br>S.O.P. |
| PSL 3068 | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR SUCT LO PRESS SW<br>STD APPLICATION |
| PSV 1002 | 201 | WILLIAMS MILL INERT GAS INLET PRESSURE SAFETY VALVE |
| PSV 1003 | 201 | LIGNITE FINES BIN CONSERVATION VENT PRESSURE SAFETY VALVE |
| PSV 1005 | 202 | AIR COMPRESSOR DSCH PRESS SAF VLV |
| PSV 1006 | 202 | PRHTR FURNACE PROCESS AIR INLT PRESS SAF VLV |
| PSV 1007 | 202 | INERT GAS PRESS SAF VLV |
| PSV 1008 | 202 | ROOTS COMPRESSOR INTR-STAGE PRESS SAF VLV |
| PSV 2004 | 204-1 | AIR SURGE TANK PRESS SAF VLV |
| PSV 2006 | 204-1 | RECYCLE FLUE GAS COMP DSCH A PRESS SAF VLV |
| PSV 2007 | 204-1 | RECYCLE FLUE GAS DSCH HDR B PRESS SAF VLV |
| PSV 2008 | 204-2 | DV CYCLE COMP A DSCH PRESS SAF VLV |
| PSV 2009 | 204-2 | RECYCLE GAS 2 DV CYCLE COMP B DSCH PRESS SAF VLV |
| PSV 2010 | 204-2 | QUENCHED FLUE GAS COMP A PRESS SAF VLV |
| PSV 2011 | 204-2 | QUENCHED FLUE GAS COMP B DSCH PRESS SAF VLV |
| PSV 2013 | 202 | LIGNITE HOPPER PURGE GAS PRESS SAF VLV |
| PSV 2014 | 205 | RG QUENCHER QUENCHED FLUE GAS OUTL PRESS SFTY VLV |
| PSV 2019-3 | 202 | LIGNITE IN HOPPER B VENT GAS PRESSURE SAFETY VALVE |
| PSV 2020 | 203-1 | WATER JACKET PRESSURE SAFETY VALVE |
| PSV 2021 | 203-1 | DOLOMITE OUT HOPPER PRESSURE SAFETY VALVE |
| PSV 2024 | 202 | PRG LINE PRESS SAF VLV |
| PSV 2025 | 204-2 | QUENCHED FUEL GAS COMPRESSOR A DSCH PRESS SAF VLV |
| PSV 2026 | 204-2 | QUENCHED FLUE GAS COMP B DSCH PRESS SAF VLV |
| PSV 2027 | 204-2 | DV CYCLE COMP A CLG WTR RTRN PRESS SAF VLV |
| PSV 2028 | 204-2 | DV CYCLE COMP B CLG WTR RTRN PRESS SAF VLV |
| PSV 2032 | 204-1 | MAIN AIR COMPRESSOR CLG WTR RTRN PRESS SAF VLV |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SPC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PSV 2033 | 204-1 | MAIN AIR COMPRESSOR 2ND STA CLG WTR RTRN PRESS SAF VLV |
| PSV 2034 | 204-1 | AIR COMPRESSOR DSCH PRESS SAF VLV |
| PSV 2035 | 204-1 | MAIN AIR COMP CLG WTR RTRN PRESS SAF VLV |
| PSV 2036 | 204-1 | MAIN AIR COMP CLG WTR RTRN PRESS SAF VLV |
| PSV 2037 | 204-1 | RECYCLE FLUE GAS COMP CLG WTR RTRN PRESS SAF VLV |
| PSV 2038 | 204-1 | RECYCLE FLUE GAS COMPRESSOR CLG WTR RTRN PRESS SAF VLV |
| PSV 2041 | 203-1 | DUMP HOPPER PURGE GAS PRESSURE SAFETY VALVE |
| PSV 2042 | 203-1 | FLARE LINE PRESSURE SAFETY/RELIEF VALVE |
| PSV 2043 | 202 | CO2 DRYER PRESS SAF VLV |
| PSV 2044 | 202 | CO2 AFTERFILTER PRESS SAF VLV |
| PSV 2045 | 204-1 | RECYCLE FLUE GAS DRYER PRESS SAF VLV |
| PSV 2046 | 204-1 | RECYCLE FLUE GAS DRYER PRESS SAF VLV |
| PSV 2047 | 204-1 | RECYCLE FLUE GAS PRESS SAF VLV |
| PSV 2048 | 204-2 | RECYCLE GAS DRYER PRESS SAF VLV |
| PSV 2049 | 204-2 | RECYCLE GAS DRYER PRESS SAF VLV |
| PSV 2050 | 204-2 | COOLING WATER RETURN LINE PRESS SAF VLV |
| PSV 2051 | 205 | ASH OUT HOPPER A INERT GAS INLET PRESS SFTY VLV |
| PSV 2052 | 205 | ASH OUT HOPPER B INERT GAS INLET PRESS SFTY VLV |
| PSV 2053 | 204-1 | AIR HEATER INLET PRESS SAF VLV |
| PSV 2054 | 204-1 | CHAR LIFT HEATER RECYCLE FLUE GAS INLT PRESS SAF VLV |
| PSV 2057 | 204-1 | DOLOMITE LIFT HTR LIFT GAS INLT PRESS SAF VLV |
| PSV 2064 | 204-1 | MAIN AIR COMPRESSOR 1ST STA CLG WTR RTRN PRESS SAF VALVE |
| PSV 2066 | 204-1 | MAIN AIR COMP 1ST STA DSCH PRESS SAF VLV |
| PSV 2067 | 204-1 | MAIN AIR COMP 2ND STA PRESS SAF VLV |
| PSV 2071 | 202 | CO2 DRYER PRESS SAF VLV |
| PSV 2072 | 204-1 | RECYCLE GAS DRYER DSCH PRESS SAF VLV |
| PSV 2073 | 204-2 | RECYCLE GAS DRYER PRESS SAF VLV |
| PSV 2075 | 204-1 | AIR SURGE TANK PRESS SAF VLV |
| PSV 2209 | 202 | PRG LINE PRESS SAF VLV |
| PSV 3001 | 205 | RG QUENCH CLR CLG WTR RETURN PRESS SFTY VLV |
| PSV 3003 | 206 | GF QUENCH COOLER CLG WTR RET PRESS SFTY VLV |
| PSV 3005 | 207 | DV QUENCH COOLER CLG WTR RET PRESS SFTY VLV S.C.P. |
| PSV 3014 | 208 | ABSORBER CONDENSER CLG WTR RET PRESS SFTY VLV IND STD-RELIEF VLVS ON PRESS VESSELS |
| PSV 3015 | 208 | STRIPPER CONDENSER CLG WTR RET PRESS SFTY VLV STD APPLICATION |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PSV 3016 | 208 | 3RD STAGE RECYCLE CO2 COMPRESSOR DSCH PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3017 | 208 | 2ND CO2 INTERCOOLER CLG WTR RET PRESS CONT VLV<br>STD APPLICATION |
| PSV 3018 | 206 | GF QUENCHER OUTL PRESS SFTY VLV |
| PSV 3019 | 207 | DV QUENCHER QUENCHED GAS OUTL PRESS SFTY VLV<br>STD DEVICE-COMMON PRACTICE |
| PSV 3023 | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR DSCH PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3024 | 208 | 1ST CO2 INTERCOOLER CLG WTR RET PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3025 | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR CLG WTR RET P SFTY VLV<br>STD APPLICATION |
| PSV 3026 | 208 | 3RD STAGE RECYCLE CO2 COMPRESSOR CLG WTR RET PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3027 | 208 | 2ND STAGE RECYCLE CO2 COMPRESSOR CLG WTR RET PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3028 | 208 | CO2 AFTERCOOLER CLG WTR RET PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3029 | 208 | 2ND STAGE RECYCLE CO2 COMPRESSOR DSCH PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3030 | 208 | HPC ABSORBER QUENCHED FLUE GAS INLET PRESS SFTY VLV<br>STD DEVICE |
| PSV 3031 | 208 | HPC ABSORBER QUENCHED FLUE GAS OUTL PRESS SFTY VLV<br>STD DEVICE |
| PSV 3032 | 208 | HPC STRIPPER CO2 OUTL PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3033 | 207 | DV QUENCHER PROCESS GAS STRM 1 INLT PRESS SFTY VLV<br>STD APPLICATION |
| PSV 3034 | 206 | QUENCH STRIPPER WASTE GAS OUTL PRESS SFTY VLV |
| PSV 5058 | 205 | INHIBITOR INJ PMP B DSCH PRESS SFTY VLV |
| PSV 5059 | 205 | INHIBITOR INJ PMP C DSCH PRESS SFTY VLV |
| PSV 5060 | 205 | INHIBITOR INJ PMP C DSCH PRESS SFTY VLV |
| PSV 5066 | 205 | INHIBITOR INJ PMP A DSCH SFTY VLV |
| PSV 5068 | 205 | INHIBITOR INJ PMP B DSCH PRESS SFTY VLV |
| PT 1000 | 201 | WILLIAMS MILL DSCH PRESSURE TRANSMITTER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SEC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PT 1010 | 202 | QUENCHED FLUE GAS PRESS XMTR |
| PT 1012 | 202 | AIR PRESS XMTR |
| PT 1027 | 202 | QUENCHED FLUE GAS PRESS XMTR |
| PT 2001 | 203-1 | DEVOLATILIZER PROCESS GAS PRESSURE TRANSMITTER |
| PT 2002A | 203-2 | REGENERATOR/DEVOLATILIZER D/P LINE PRESS XMTR |
| PT 2011 | 203-1 | DOLOMITE OUT HOPPER DSCH PRESSURE TRANSMITTER |
| PT 2022 | 203-1 | PROCESS GAS 2 PRESSURE TRANSMITTER |
| PT 2036 | 204-1 | AIR SURGE TANK PRESS XMTR |
| PT 2041 | 204-1 | RECYCLE GAS PRESS XMTR |
| PT 2052 | 204-2 | RECYCLE GAS 2 PRESS XMTR |
| PT 2053 | 204-2 | DV CYCLE COMP DSCH PRESS XMTR |
| PT 2054 | 204-2 | QUENCHED FLUE GAS LINE PRESS XMTR |
| PT 2055 | 204-2 | QUENCHED FLUE GAS PRESS |
| PT 2064 | 202 | INERT GAS PRESSURE XMTR |
| PT 2065 | 202 | PURGE GAS PRESS XMTR |
| PT 2071 | 202 | QUENCHED FUEL GAS PRESS XMTR |
| PT 2098 | 203-1 | ENGAGER POT PRESSURE TRANSMITTER |
| PT 2098A | 203-2 | SPENT CHAR LINE D/P LINE PRESSURE XMTR |
| PT 2113 | 204-1 | RECYCLE GAS CHAR LIFT PRESS XMTR |
| PT 2123 | 203-1 | ENGAGER POT PRESSURE TRANSMITTER |
| PT 2224 | 205 | ASH OUT HOPPER A RELIEF VENT GAS PRESS XMTR |
| PT 2225 | 205 | ASH OUT HOPPER B RELIEF VENT GAS PRESS XMTR |
| PT 3009 | 207 | WASTE GAS TO FLARE PRESS XMTR<br>STD DEVICE |
| PT 3028 | 205 | RG CYCLONE FLUE GAS OUTL PRESS XMTR |
| PT 3046 | 208 | ABSORBER CONDENSER OUTL PRESS XMTR<br>STD DEVICE |
| PT 3051 | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR SUCT PRESS XMTR<br>STD DEVICE |
| PT 3063 | 208 | RECYCLE CO2 PRESS XMTR<br>STD DEVICE |
| RO 1029 | 202 | INERT GAS RESTRICTION ORIFICE |
| RO 1030 | 202 | INERT GAS RESTRICTION ORIFICE |
| RO 1035 | 201 | LIGNITE CYCLONE OUTLET INERT GAS SUPPLY RESTRICTION ORIFICE |
| RO 1036 | 201 | LIGNITE CYCLONE INLET INERT GAS SUPPLY RESTRICTION ORIFICE |
| RO 2184 | 204-1 | RECYCLE FLUE GAS DRYER RESTRICTION ORIFICE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| RO 2185 | 204-2 | RECYCLE GAS DRYER REGEN RESTRICTION ORIFICE |
| RO 2186 | 202 | CO2 DRYER RSTRTN ORIF |
| RO 2190 | 204-1 | AIR HEATER COMBUSTION ELEMENT SPARGE RESTRICTION ORIF |
| RO 2191 | 204-1 | DOLOMITE LIFT HEATER COMBUSTION ELMT SPARGE REST ORIF |
| RO 2192 | 204-1 | CHAR LIFT HEATER COMB ELMT SPARGE AIR RESTRICTION ORIFICE |
| RO 2193 | 204-1 | AIR HEATER INLET INERT GAS RESTRICTION ORIFICE |
| RO 2217 | 203-1 | DOLOMITE RECYCLE FLUE GAS INLET RESTRICTION ORIFICE |
| RO 2218 | 203-1 | DEVOLATILIZER RECYCLE GAS DSCH VLV PURGE GAS RESTRICTION ORF |
| RO 2219 | 203-1 | WASTE DOLOMITE INLT VLV PURGE GAS RESTRICTION ORIFICE |
| RO 2220 | 203-1 | SUMP HOPPER WASTE DOLOMITE INLT VLV PURGE RESTRICTION ORIF |
| RO 2221 | 203-1 | SPENT DOLOMITE LIN VLV PURGE GAS RESTRICTION ORIFICE |
| RO 2222 | 203-1 | SPENT DOLOMITE DSCH VALVE PURGE RESTRICTION ORIFICE |
| RO 2224 | 203-1 | CHAR DSCH CV PURGE GAS RESTRICTION ORIFICE |
| RO 2226 | 203-1 | PURGE GAS B RESTRICTION ORIFICE |
| RO 2227 | 203-1 | PURGE GAS B RESTRICTION ORIFICE |
| RO 2231 | 203-1 | DEVOLATILIZER HEATER PURGE GAS SUPPLY RESTRICTION ORIFICE |
| RO 2232 | 203-1 | DEVOLATILIZER HEATER PURGE GAS SUPPLY RESTRICTION ORIFICE |
| RO 2234 | 203-1 | GASIFIER RECYCLE GAS 2 INLET RESTRICTION ORIFICE |
| RO 2235 | 203-1 | GASIFIER RECYCLE GAS 2 INLET RESTRICTION ORIFICE |
| RO 2261 | 203-1 | RECYCLE GAS BY-PASS LINE RESTRICTION ORIFICE |
| RO 2262 | 203-1 | PURGE GAS B RESTRICTION ORIFICE |
| RO 2263 | 203-1 | SPENT DOLOMITE CV PURGE GAS RESTRICTION ORIFICE |
| RO 2266 | 203-1 | RECYCLE GAS WASTE DOLOMITE VALVE PURGE RESTRICTION ORIFICE |
| RO 2282 | 205 | ASH OUT HOPPER A INLT CV GAS PURGE RESTRICTIVE ORIFICE |
| RO 2283 | 205 | ASH OUT HOPPER B INLT CV GAS PURGE RESTRICTIVE ORIFICE |
| RO 3020 | 207 | DV QUENCH SEPARATOR BLR FEED WTR INLT RESTRICTIVE ORIFICE STD DEVICE |
| RO 3021 | 206 | GF QUENCH SEPARATOR BLR FEED WTR INLT RESTRICTIVE ORIFICE |
| RO 5034 | 204-2 | QUENCHED FLUE GAS COMP A CLG WTR RTRN RESTRICTION ORIFICE |
| RO 5035 | 204-2 | QUENCHED FLUE GAS COMP B CLG WTR RTRN RESTRICTION ORIFICE |
| RO 5036 | 204-1 | QUENCHED FLUE GAS COOLING WATER RTRN RESTRICTION ORIFICE |
| RO 5037 | 204-1 | QUENCHED FLUE GAS COOLING WATER RTRN RESTRICTION ORIFICE |
| RO 5038 | 204-2 | DV CYCLE COMP A CLG WTR RTRN RESTRICTION ORIFICE |
| RO 5039 | 204-2 | DV CYCLE COMP B CLG WTR RTRN RESTRICTION ORIFICE |
| RO 5047 | 201 | DOLOMITE SILO A PLANT AIR SUPPLY RESTRICTION ORIFICE |
| RO 5048 | 201 | DOLOMITE SILO B PLANT AIR SUPPLY RESTRICTION ORIFICE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| SCV 1059 | 201 | BAG HOUSE COOLING WATER SUPPLY SOLENOID VALVE |
| SI 2054 | 202 | LIGNITE HOPPER A FEEDER MOTOR SPEED INDICATOR |
| SI 2055 | 202 | LIGNITE HOPPER B FEEDER MOTOR SPEED INDICATOR |
| SI 2056 | 203-1 | DOLOMITE HOPPER ROTARY VALVE MOTOR SPEED INDICATOR |
| TCV 1000 | 201 | DRYER FURNACE TEMPERATURE CONTROL VALVE |
| TCV 1010 | 202 | PRHTR FUNACE FUEL GAS TEMP CONT VLV |
| TCV 2030 | 203-1 | GASIFIER DOLOMITE SUPPLY TEMPERATURE CONTROL VALVE |
| TCV 2047 | 204-1 | AIR HEATER TEMP CONT VLV |
| TCV 2050 | 204-1 | DOLOMITE LIFT GAS TEMP CONT VLV |
| TCV 2054 | 204-1 | HOT CHAR LIFT GAS TEMP CONT VLV |
| TCV 2073 | 203-3 | DV STEAM DRUM TEMP CONT VLV |
| TCV 2074 | 203-3 | RG STEAM DRUM COND TEMP CONT VALVE |
| TCV 2075 | 203-3 | GASIFIER JACKET WATER TEMP CONT VALVE |
| TCV 3012 | 207 | DV QUENCHER PROCESS GAS STRM 1 INLT TEMP CONT VLV<br>STD STATE OF ART OK |
| TE 1002 | 201 | DRYER FURNACE OUTLET TEMPERATURE ELEMENT |
| TE 1006 | 201 | MILL SEPARATOR OUTLET TEMPERATURE ELEMENT |
| TE 1007 | 201 | MILL SEPARATOR OUTLET TEMPERATURE ELEMENT |
| TE 1008 | 201 | LIGNITE CYCLONE INLET TEMPERATURE ELEMENT |
| TE 1009 | 201 | LIGNITE CYCLONE VENT GAS TEMPERATURE ELEMENT |
| TE 1010 | 202 | WASTE LIGNITE TEMP ELMT |
| TE 1012 | 202 | LIGNITE PRHTR TEMP ELMT |
| TE 1013 | 202 | LIGNITE PRHTR TEMP ELMT |
| TE 1014 | 202 | LIGNITE PRHTER TEMP ELMT |
| TE 1015 | 202 | PRHTR FURNACE INERT GAS TEMP ELMT |
| TE 1020 | 202 | WASTE LIGNITE TEMP ELMT |
| TE 1023 | 201 | INERT GAS INLET TEMPERATURE ELEMENT<br>TO TR 1001 |
| TE 1024 | 201 | INERT GAS INLET TEMPERATURE ELEMENT<br>TO TR 1001 |
| TE 1025 | 201 | INERT GAS INLET TEMPERATURE ELEMENT<br>TO TR 1001 |
| TE 1026 | 201 | INERT GAS INLET TEMPERATURE ELEMENT<br>TO TR 1001 |
| TE 1027 | 201 | INERT GAS INLET TEMPERATURE ELEMENT<br>TO TR 1001 |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TE 1028 | 201 | INERT GAS INLET TEMPERATURE ELEMENT TO TR 1001 |
| TE 1029 | 201 | SECONDARY FAN SUCTION TEMPERATURE ELEMENT |
| TE 2001A | 203-1 | DEVOLATILIZER VAPOR SPACE TEMPERATURE ELEMENT TR 2000-8 |
| TE 2001B | 203-1 | DEVOLATILIZER VAPOR SPACE TEMPERATURE ELEMENT TR 2000-12 |
| TE 2002 | 203-1 | DEVOLATILIZER VAPOR SPACE TEMPERATURE ELEMENT TR 2000-7 |
| TE 2003 | 203-1 | DEVOLATILIZER VAPOR SPACE TEMPERATURE TR 2000-6 |
| TE 2004 | 203-1 | DEVOLATILIZER FLUID BED TEMPERATURE ELEMENT TR 2000-9 |
| TE 2005 | 203-1 | DEVOLATILIZER FLUID BED TEMPERATURE ELEMENT TR 2000-13 |
| TE 2006 | 203-1 | DEVOLATILIZER FLUID BED TEMPERATURE ELEMENT TR 2000-10 |
| TE 2007 | 203-1 | DEVOLATILIZER FLUID BED TEMPERATURE ELEMENT TR 2000-14 |
| TE 2008 | 203-1 | DEVOLATILIZER RECYCLE GAS SUPPLY TEMPERATURE ELEMENT TR 2000-16 |
| TE 2009 | 203-1 | DEVOLATILIZER SPENT DOLOMITE POT TEMPERATURE ELEMENT TR 2000-11 |
| TE 2010 | 203-1 | RECYCLE GAS TEMPERATURE ELEMENT TR 2000-5 |
| TE 2012 | 203-1 | GASIFIER CHAR DSCH LINE TEMPERATURE ELEMENT |
| TE 2013 | 203-1 | DOLOMITE LIFT GAS TEMPERATURE ELEMENT TR 2016-8 |
| TE 2026 | 203-1 | REGENERATOR AIR INLET TEMPERATURE ELEMENT |
| TE 2027 | 203-1 | SPENT DOLOMITE LINE TEMPERATURE ELEMENT |
| TE 2028 | 203-1 | SPENT CHAR LINE TEMPERATURE RECORDER TR 2016-5 |
| TE 2032A | 203-1 | GASIFIER VAPOR SPACE TEMPERATURE ELEMENT |
| TE 2033 | 203-1 | GASIFIER VAPOR SPACE TEMPERATURE ELEMENT TR 2000-7 |
| TE 2035 | 203-1 | GASIFIER FLUID BED TEMPERATURE ELEMENT |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TE 2037 | 203-1 | GASIFIER FLUID BED TEMPERATURE ELEMENT |
| TE 2039 | 203-1 | GASIFIER POT TEMPERATURE ELEMENT |
| TE 2040 | 203-1 | RECYCLE GAS STREAM 2 TEMPERATURE ELEMENT<br>TR 2000-1 |
| TE 2041 | 203-1 | SPENT CHAR LIFT GAS TEMPERATURE ELEMENT<br>TR 2016-4 |
| TE 2047 | 204-1 | AIR HEATER TEMPERATURE ELEMENT |
| TE 2050 | 204-1 | DOLOMITE LIFT HTR TEMP ELMT |
| TE 2054 | 204-1 | HOT CHAR LIFT GAS TEMP ELMT |
| TE 2070 | 202 | LIGNITE HOPPERS INLT TEMP ELMT |
| TE 2071 | 203-1 | WASTE DOLOMITE STORAGE HOPPER SKIN TEMPERATURE ELEMENT |
| TE 2073 | 203-3 | DV STEAM DRUM COND DSCH TEMP ELMT |
| TE 2074 | 203-3 | RG JACKET WATER COND TEMP ELMT |
| TE 2075 | 203-3 | GASIFIER JACKET WATER RETURN TEMP ELMT |
| TE 2079 | 203-1 | DEVOLATILIZER SPENT DOLOMITE POT TEMPERATURE ELEMENT<br>TR 2000-15 |
| TE 2108 | 205 | RG CYCLONE INLT TEMP ELEMENT |
| TE 2115 | 204-1 | AIR HEATER INLET TEMP ELMT |
| TE 2118 | 204-1 | HOT CHAR LIFT GAS TEMP ELMT<br>UNLISTED - TI 2001 |
| TE 2130 | 204-1 | DOLOMITE LIFT HTR RECYCLE FLUE GAS DSCH TEMP ELMT |
| TE 2137 | 203-1 | FLUE GAS HEAT TRACE TEMPERATURE ELEMENT |
| TE 2138 | 203-1 | PIPE JACKET WATER TEMPERATURE ELEMENT |
| TE 2160 | 203-1 | WASTE DOLOMITE STORAGE HOPPER TEMPERATURE ELEMENT<br>FIRST OF SIX ELEMENTS POINT SELECT OR AVG ARE STANDARD |
| TE 2161 | 203-1 | WASTE DOLOMITE STORAGE HOPPER TEMPERATURE ELEMENT<br>SEE TE 2160 |
| TE 2162 | 203-1 | WASTE DOLOMITE STORAGE HOPPER TEMPERATURE ELEMENT<br>SEE TE 2160 |
| TE 2164 | 203-1 | WASTE DOLOMITE STORAGE HOPPER TEMPERATURE ELEMENT<br>SEE TE 2160 |
| TE 2165 | 203-1 | WASTE DOLOMITE STORAGE HOPPER TEMPERATURE ELEMENT<br>SEE TE 2160 |
| TE 2166 | 204-1 | AIR HEATER STACK TEMP ELMT |
| TE 2167 | 204-1 | AIR HEATER INLT TEMP ELMT |
| TE 2168 | 204-1 | DOLOMITE LIFT HTR STACK TEMP ELMT |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TE 2169 | 204-1 | DOLOMITE LIFT HTR LIFT GAS DSCH TEMP ELMT |
| TE 2170 | 204-1 | CHAR LIFT HEATER STACK TEMP ELMT |
| TE 2171 | 204-1 | CHAR LIFT HEATER HOT GAS OUTL TEMP ELMT<br>IN HEATER |
| TE 2201 | 207 | PROCESS GAS STRM 1 CLG JACKET WTR RET TEMP ELEM<br>TEMP STDS WELL DOCUMENTED |
| TE 2202 | 203-1 | PROCESS GAS 2 HEAT TRACE TEMPERATURE ELEMENT<br>TR 2016-2 |
| TE 2212 | 203-1 | DUMP HOPPER TEMPERATURE ELEMENT |
| TE 2215 | 202 | LIGNITE HOPPER DSCH TEMP ELMT |
| TE 2216 | 202 | LIGNITE FDR B DSCH TEMP ELMT |
| TE 2217 | 203-1 | FLUE GAS TEMPERATURE ELEMENT<br>TR 2016-6 |
| TE 2218 | 203-1 | PROCESS GAS 2 HEAT TRACE TEMPERATURE ELEMENT |
| TE 2220 | 203-1 | PROCESS GAS 2 HEAT TRACE TEMPERATURE ELEMENT<br>TR 2016-1 |
| TE 2278 | 204-1 | HOT CHAR LIFT GAS TEMP ELMT |
| TE 2279 | 204-1 | AIR HEATER TEMPERATURE ELEMENT |
| TE 2280 | 204-1 | DOLOMITE LIFT HTR LIFT GAS INLT TEMP ELMT |
| TE 2286 | 203-1 | ENGAGER POT SPENT DOLOMITE INLET TEMPERATURE ELEMENT |
| TE 2287C | 203-1 | REGENERATOR AIR TEMPERATURE ELEMENT (ROTARY VALVE PURGE) |
| TE 2288 | 203-1 | SPENT DOLOMITE DISCHARG TEMPERATURE ELEMENT |
| TE 2289 | 203-1 | REGENERATOR SPENT DOLOMITE LINE TEMPERATURE ELEMENT |
| TE 2290 | 203-1 | SPENT DOLOMITE TEMPERATURE ELEMENT |
| TE 2291 | 203-1 | REGENERATOR BOTTOM SKIN TEMPERATURE INDICATOR |
| TE 2309 | 203-1 | GASIFIER SPENT DOLOMITE BED TEMPERATURE ELEMENT<br>TR 2000-3 |
| TE 2310C | 203-1 | CV CYCLONE DOLOMITE TEMPERATURE ELEMENT |
| TE 2311C | 203-1 | DV CYCLONE DOLOMITE TEMPERATURE ELEMENT |
| TE 2312C | 203-1 | DV CYCLONE DOLOMITE TEMPERATURE ELEMENT |
| TE 2313 | 203-1 | DV CYCLONE DOLOMITE TEMPERATURE ELEMENT |
| TE 2314 | 203-1 | GASIFIER JACKET TEMPERATURE ELEMENT |
| TE 2315 | 203-1 | DV CYCLONE VAPOR SPACE TEMPERATURE ELEMENT |
| TE 2318 | 203-1 | DOLOMITE VALVE TEMPERATURE ELEMENT |
| TE 2319 | 203-1 | GASIFIER FLUID BED TEMPERATURE ELEMENT |
| TE 3001 | 205 | RG QUENCHER QUENCHED FLUE GAS OUTL TEMP ELEM |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SFC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TE 3006 | 206 | GF QUENCHER OUTL TEMP ELEM |
| TE 3009 | 207 | DV QUENCHER QUENCHED GAS OUTL TEMP ELEM<br>STD DEVICE |
| TE 3047 | 207 | DV QUENCHER PROCESS GAS STRM 1 INLT TEMP ELEM<br>STD DEVICE |
| TE 3061 | 208 | ABSORBER CONDENSER OUTL TEMP ELEM<br>STD DEVICES SHOULD SCALE UP |
| TE 3096 | 208 | HPC STRIPPER CARBONATE SOLUTION OUTL TEMP ELEM<br>STD DEVICE |
| TE 3114 | 205 | RG QUENCH PMPS SUCTION HDR TEMP ELEMENT |
| TE 3115 | 206 | GF QUENCH PMPS SUCT HDR TEMP ELEM |
| TE 3116 | 207 | DV QUENCH SEPARATOR QUENCH WTR OUTL TEMP ELEM<br>STD DEVICE |
| THC 2014 | 203-1 | DEVOLATILIZER SOLENOID VALVE MANUAL TEMP CONTROL<br>MAY HAVE BEEN FURNISHED FOR A DEVICE NOT CONTROLLED |
| THC 2030 | 203-1 | DOLOMITE SUPPLY VALVE MANUAL TEMPERATURE CONTROL |
| TI 1003U | 203-3 | 3 UNLISTED TEMPERATURE INDICATORS |
| TI 1004U | 205 | 4 UNLISTED TEMP IND<br>STD UNITS-NO CONTROL<br>TC/BI-METALLIC |
| TI 1004V | 206 | 4 UNLISTED TEMP IND<br>STD UNITS-NO CONTROL<br>APPEARS AS BI-METALLIC |
| TI 1005-U | 207 | 5 UNLISTED TEMP IND<br>STD DEVICE |
| TI 1008U | 202 | 8 UNLISTED TEMP IND<br>INDICATORS READILY AVALIABLE NO CONTROL<br>VAPOR FILLED,TC,OR BI-METALLIC DEPENDING ON PREFERENCE |
| TI 1011U | 204-2 | 11 UNLISTED TEMP IND<br>STD UNITS-NO CONTROL<br>COULD BE BI-METALLIC OR HG FILLED |
| TI 1017U | 208 | 17 UNLISTED TEMPIND<br>STD DEVICES |
| TI 1025U | 204-1 | 25 UNLISTED TEMP IND<br>READILY AVAILABLE-QUITE RELIABLE-NO CONTROL<br>MISC/VAPOR FILLED/TC/BI-METALLIC? |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TI 2001 | 203-1 | WASTE DOLOMITE HOPPER TEMPERATURE INDICATOR |
| TI 2142 | 203-1 | FLUE GAS HEAT TRACE FLUID TEMP IND |
| TI 2143 | 203-1 | PIPE JACKET WATER TEMPERATURE |
| TI 2210 | 203-1 | PROCESS GAS 2 HEAT TRACE TEMPERATURE INDICATOR |
| TISH 1002 | 201 | DRYER FURNACE OUTLET TEMPERATURE INDICATING SWITCH HIGH<br>ALARM CONNECTION NOT SHOWN |
| TISH 1021 | 202 | PRHTR FURNACE INERT GAS OUTL TEMP IND SW HI |
| TISH 2071 | 203-1 | WASTE DOLOMITE STORAGE HOPPER SKIN TEMP IND SWITCH HIGH |
| TISH 2166 | 204-1 | AIR HEATER STACK TEMP IND SW HI |
| TISH 2167 | 204-1 | AIR HEATER INLT TEMP IND SW HI |
| TISH 2168 | 204-1 | DOLOMITE LIFT HTR STACK IND TEMP SW HI |
| TISH 2169 | 204-1 | DOLOMITE LIFT GAS HTR RECYCLE FLUE GAS DSCH TEMP IND SW HI |
| TISH 2170 | 204-1 | CHAR LIFT HEATER TEMP IND SW HI |
| TISH 2171 | 204-1 | HOT CHAR LIFT GAS TEMP IND SW HI |
| TISH 2177 | 204-1 | MAIN AIR COMPRESSOR CLG WTR RTRN IND TEMP SW HI |
| TM 1010 | 202 | WASTE LIGNITE TEMP CONVERTOR |
| TM 1020 | 202 | WASTE LIGNITE TEMP XDCR |
| TM 2047 | 204-1 | AIR HEATER TEMP SIGNAL CONVERTER |
| TM 2050 | 204-1 | DOLOMITE LIFT HTR TEMP CNVRTR |
| TM 2054 | 204-1 | HOT CHAR LIFT GAS TEMP CVTR |
| TM 2073 | 203-3 | DV STEAM DRUM COND DSCH TEMP CVTR |
| TM 2074 | 203-3 | RG JACKET WATER COND MANUAL SET POINT TEMP CONT |
| TM 2075 | 203-3 | GASIFIER JACKET WATER TEMP S/CVTR |
| TR 1001 | 201 | LOCAL PANEL MOUNTED TEMPERATURE RECORDER MULTI-POINT<br>13 POINTS THIS DWG |
| TR 1001-2 | 202 | 4 PT TEMPERATURE RECORDER |
| TR 2000-2 | 202 | 1 PT ON MULTI-PT TEMP RCDR<br>TEMP RCDRS GENERALLY RELIABLE<br>POSSIBLY RTD OR TC |
| TR 2000-3 | 203-1 | 25 MISC TEMP POINTS RCDR<br>READILY AVAILABLE AND RELIABLE<br>TC OR VAPOR FILLED DEPENDING ON TEMP RANGE |
| TR 2016 | 207 | PROCESS GAS STRM 1 CLG JACKET WTR RET TEMP REC<br>STD DEVICE |
| TR 2016-2 | 202 | 2 PT ON MULTI-POINT TEMP REC<br>TEMP RECORDERS ARE RELIABLE<br>CAN BE TC OR RTD |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TR 2016-3 | 203-1 | TEMPERATURE RECORDER 8 POINTS<br>FEW PROBLEMS WITH TEMP RCDRS<br>POSSIBLY TC OR RTD |
| TR 2082 | 203-3 | DEVOLATILIZER JACKET WATER VAPOR DSCH TEMP RCDR |
| TR 2083 | 203-3 | RG JACKET WATER VAPOR OUTL TEMP RCDR |
| TR 2084 | 203-3 | GASIFIER JACKET WATER VAPOR OUTLET TEMP REC |
| TR 2284 | 204-1 | HOT CHAR LIFT GAS TEMP RCDR<br>3 DEVICES |
| TR 2284A | 204-1 | DOLOMITE LIFT HTR RECYCLE FLUE GAS INLT TEMP RCDR |
| TR 2284B | 204-1 | AIR HTR OUTL TEMP RCDR |
| TR 3000-A | 207 | 3 UNLISTED TEMP RCDR POINTS<br>STD DEVICE<br>TE 3009,3047 & 3116. TWS ARE NOT LISTED-5 |
| TR 3000-B | 209 | 1 POINT MISC TEMP RCDR<br>STD DEVICE - NO CONTROL |
| TR 3000-3 | 203-1 | 5 POINT TEMP RCDR<br>PRESENT RCDRS RUGGED AND RELIABLE<br>TC OR VAPOR FILLED RELATED TO TEMP RANGE |
| TR 3000-9 | 206 | QUENCH WTR RTRN TEMP RCDR PT ON MULTI-PT<br>STD UNIT VERY RELIABLE<br>POSSIBLY TC OR RTD |
| TRC 1000 | 201 | MILL SEPARATOR TEMPERATURE RECORDING CONTROLLER |
| TRC 1010 | 202 | WASTE LIGNITE TEMP RECORDING CONT |
| TRC 2047 | 204-1 | AIR HEATER TEMP REC CONT |
| TRC 2050 | 204-1 | DOLOMITE LIFT GAS HTR REC TEMP CONT |
| TRC 2054 | 204-1 | HOT CHAR LIFT GAS TEMP REC CONT |
| TRC 2073 | 203-3 | DV STEAM DRUM REC TEMP CONT |
| TRC 2074 | 203-3 | RG JACKET WATER VAPOR CONDENSATE TEMP REC CONT |
| TRC 2075 | 203-3 | GASIFIER JACKET WATER RETURN TEMP REC CONT |
| TSH 1000 | 201 | MILL SEPARATOR TEMPERATURE SWITCH HIGH |
| TSH 1002 | 201 | DRYER FURNACE OUTLET TEMPERATURE SWITCH HIGH |
| TSH 1005 | 201 | SECONDARY FAN SUCTION TEMPERATURE SWITCH HIGH |
| TSH 1009 | 201 | LIGNITE CYCLONE VENT GAS TEMPERATURE SWITCH HIGH |
| TSH 1010 | 202 | WASTE LIGNITE TEMP SW HI |
| TSH 1015 | 202 | PRETR FURNACE INERT GAS OUTL TEMP SW HI<br>OF TR 1001 TO XA-1000-2 |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TSH 2027 | 203-1 | SPENT DOLOMITE DSCH TEMPERATURE SWITCH HIGH |
| TSH 2047 | 204-1 | AIR HEATER TEMPERATURE SW HI |
| TSH 2050 | 204-1 | DOLOMITE LIFT GAS TEMP SW HI |
| TSH 2054 | 204-1 | HOT CHAR LIFT GAS TEMP SW HI |
| TSH 2094 | 204-2 | QUENCHED FLUE GAS COMP A TEMP SW HI |
| TSH 2098 | 204-2 | QUENCHED FLUE GAS COMP B DSCH TEMP SW LO |
| TSH 2102 | 204-2 | DV CYCLE COMP A SUCTION TEMP SW HI |
| TSH 2106 | 204-2 | DV CYCLE COMP B SUCTION TEMP SW HI |
| TSH 2108 | 205 | RG CYCLONE INLET TEMP SW HI |
| TSH 2133 | 204-1 | RECYCLE FLUE GAS COMP DSCH A TEMP SW HI |
| TSH 2136 | 204-1 | RECYCLE FLUE GAS COMP DSCH HDR B TEMP SW HI |
| TSH 2137 | 203-1 | FLUE GAS TEMPERATURE SWITCH HIGH |
| TSH 2138 | 203-1 | PIPE JACKET WATER TEMPERATURE SWITCH HIGH |
| TSH 2173 | 204-1 | MAIN AIR COMP 1ST STA AFTERCOOLER INLT TEMP SW HI |
| TSH 2174 | 204-1 | MAIN AIR COMP SECOND STAGE TEMP SW HI |
| TSH 2175 | 204-1 | AIR COMPRESSOR 3RD STAGE CLG WTR TEMP SW HI |
| TSH 2201 | 207 | PROCESS GAS STRM 1 CLG JACKET WTR RET HI TEMP SW<br>STD DEVICES-RELATIVELY STABLE |
| TSH 2202 | 203-1 | PROCESS GAS 2 HEAT TRACE TEMPERATURE SWITCH HIGH |
| TSH 2203 | 204-2 | QUENCHED FLUE GAS COMP A CLG WTR RTRN TEMP SW HI |
| TSH 2204 | 204-2 | QUENCHED FLUE GAS COMP B CLG WTR RTRN TEMP SW HI |
| TSH 2205 | 204-2 | DV CYCLE COMP A CLG WTR RTRN TEMP SW HI |
| TSH 2206 | 204-2 | DV CYCLE COMP B CLG WTR RTRN TEMP SW HI |
| TSH 2207 | 204-1 | RECYCLE FLUE GAS COMP CLG WTR RTRN TEMP SW HI |
| TSH 2208 | 204-1 | RECYCLE FLUE GAS COMP CLG WTR RTRN TEMP SW HI |
| TSH 2214 | 204-1 | MAIN AIR COMP 1ST STA AFTER COOLER INLT TEMP ANNUNC |
| TSH 2219 | 203-1 | FUEL GAS HEAT TRACE TEMPERATURE SWITCH HIGH |
| TSH 2220 | 203-1 | PROCESS GAS 2 HEAT TRACE TEMPERATURE SWITCH HIGH |
| TSH 2223 | 204-1 | 2/3 STAGE COMP CLG WTR RTRN TEMP SW HI |
| TSH 3001 | 205 | RG QUENCHER QUENCHED FLUE GAS OUTL TEMP SW HI |
| TSH 3006 | 206 | GF QUENCHER OUTL TEMP SW HI |
| TSH 3009 | 207 | DV QUENCHER QUENCHED GAS OUTL HI TEMP SW<br>STD DEVICE |
| TSH 3047 | 207 | DV QUENCHER PROCESS GAS STRM 1 INLT HI TEMP SW<br>STD DEVICE |
| TSH 3105 | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR DSCH HI TEMP SW<br>STD APPLICATION |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TSH 3106 | 208 | 2ND STAGE RECYCLE CO2 COMPRESSOR DSCH HI TEMP SW |
| | | STD APPLICATION |
| TSH 3107 | 208 | 3RD STAGE RECYCLE CO2 COMPRESSOR DSCH HI TEMP SW |
| | | STD APPLICATION |
| TSH 3110 | 208 | FIRST STAGE RECYCLE CO2 COMPRESSOR CLG WTR RET HI TEMP SW |
| | | STD APPLICATION |
| TSH 3111 | 208 | 2ND STAGE RECYCLE CO2 COMPRESSOR CLG WTR RET HI TEMP SW |
| | | STD APPLICATION |
| TSH 3112 | 208 | 3RD STAGE RECYCLE CO2 COMPRESSOR CLG WTR RET HI TEMP SW |
| | | STD APPLICATION |
| TSH 3114 | 205 | RG QUENCH PMPS SUCTION HDR TEMP SW HI |
| TSH 3115 | 206 | GF QUENCH PMPS SUCT HDR TEMP SW HI |
| TSH 3116 | 207 | DV QUENCH SEPARATOR QUENCH WTR OUTL HI TEMP SW |
| | | STD DEVICE |
| TSL 1000 | 201 | MILL SEPARATOR TEMPERATURE SWITCH LOW |
| TT 2082 | 203-3 | DEVOLATILIZER JACKET WATER VAPOR DSCH TEMP XMTR |
| TT 2083 | 203-3 | RG JACKET WATER VAPOR TEMP XMTR |
| TT 2084 | 203-3 | GASIFIER JACKET WATER VAPOR OUTLET TEMP XMTR |
| WI 2032 | 202 | LIGNITE HOPPER A WEIGHT IND |
| WI 2033 | 202 | LIGNITE FEEDER B WEIGHT IND |
| WR 2032 | 202 | LIGNITE FDR B WT REC |
| WR 2033 | 202 | LIGNITE FDR B WT REC |
| WSL 2032-1 | 202 | LIGNITE FDR A WT SW LO |
| WSL 2032-2 | 202 | LIGNITE FDR A WT SW LO |
| WSL 2033-1 | 202 | LIGNITE FDR WEIGH SW LO |
| WSL 2099 | 202 | LIGNITE FDR B WT SW LO |
| XA 1000-1 | 201 | 17 MISC ANNUNCIATOR POINTS |
| | | STD METHOD AND DEVICES FOR ALARM |
| | | REMOTE SWITCH OPERATED ALARM |
| XA 1000-2 | 202 | 6 MISC ANNUNCIATOR POINTS |
| | | STANDARD READILY AVAILABLE DEVICES |
| | | REMOTE SWITCH OPERATED ALARM |
| XA 2000-A | 207 | 2 UNLISTED ANNUNC POINTS |
| | | STD DEVICE |
| XA 2000-2 | 202 | 2 UNLISTED ANNUNCIATOR POINTS |
| XA 2000-3 | 203-1 | 21 POINT MISC ANNUNCIATOR |
| | | STANDARD-READILY AVAILABLE |
| | | REMOTE SWITCH ACTUATED |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE $CO_2$ ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XA 2000-5 | 203-3 | 13 MISC ANNUNC POINTS UNLISTED<br>STD METHOD & DEVICES TO ALARM<br>REMOTE SWITCH OPTD DEVICES |
| XA 2000-6 | 204-1 | 7 MISC ANNUNCIATOR POINTS<br>STANDARD READILY AVAILABLE DEVICES<br>REMOTE SWITCH OPERATED ALARMS |
| XA 2000-7 | 204-2 | 8 UNLISTED MISC ANNUNCIATOR POINTS<br>STD UNITS VERY RELIABLE<br>REMOTE SWITCH ACTUATED ALARMS |
| XA 2000-8 | 205 | 8 UNLISTED ANNUNCIATOR POINTS |
| XA 2105 | 202 | FIFTH FLOOR ANNUNC |
| XA 2106 | 202 | FLOOR 6 ANNUNC |
| XA 2118A | 204-1 | AIR HEATER INLET LOW FLOW ANNUNC |
| XA 2118B | 204-1 | AIR HEATER OUTLET HIGH TEMP ANNUNC |
| XA 2118C | 204-1 | AIR HEATER FLAME OUT ANNUNC<br>2 XH |
| XA 2118D | 204-1 | DOLOMITE LIFT GAS HTR STACK HI TEMP ANNUNC<br>2 XH |
| XA 2118E | 204-1 | DOLOMITE LIFT GAS HTR INLET LOW FLOW ANNUNC |
| XA 2118G | 204-1 | DOLOMITE LIFT GAS HTR FLAME OUT ANNUNC |
| XA 2118H | 204-1 | CHAR LIFT GAS HEATER STACK HI TEMP ANNUNC |
| XA 2118I | 204-1 | CHAR LIFT GAS HEATER INLET LO FLOW ANNUNC |
| XA 2118J | 204-1 | CHAR LIFT GAS HEATER OUTLET HI TEMP ANNUNC |
| XA 2118K | 204-1 | CHAR LIFT GAS HEATER FLAME OUT ANNUNC |
| XA 2133A | 204-1 | MAIN AIR COMPRESSOR 1ST STA A HI WTR TEMP ANNUNC |
| XA 2133B | 204-1 | MAIN AIR COMPRESSOR 1ST STA B HI WTR TEMP |
| XA 2133C | 204-1 | COMP LUBE OIL CLR WTR INLT TEMP HI ANNUNC |
| XA 2133D | 204-1 | MAIN AIR COMP 3RD STA CLR TEMP HI ANNUNC |
| XA 2133E | 204-1 | MAIN AIR COMP 2ND STA CLR TEMP HI ANNUNC |
| XA 2133F | 203-3 | 2/3 STAGE COMP CLG WTR RTRN TEMP HI ANNUNC |
| XA 2135 | 204-1 | MAIN AIR COMPRESSOR LOW LUBE OIL PRESS ANNUNC<br>VENDOR PKG |
| XA 3000-A | 207 | UNLISTED ANNUNC POINTS-10<br>STD DEVICE |
| XA 3000-B | 208 | 7 MISC ANNUNC POINTS<br>STD DEVICE - NO PROBLEMS<br>REMOTE SWITCH OPTD ALARM |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XA 3000-8 | 205 | 6 UNLISTED MISC ANNUNCIATOR POINTS<br>STD UNITS VERY RELIABLE<br>REMOTE SW ACTUATED ALARMS |
| XA 3000-9 | 206 | 11 UNLISTED MISC ANNUNC PTS<br>STD UNITS VERY RELIABLE<br>REMOTE SW ACTUATED ALMS |
| XCV 1001 | 201 | INERT GAS SUPPLY CONTROL VALVE |
| XCV 1002 | 201 | DRYER FURNACE START-UP STACK AUTO DAMPER |
| XCV 1003 | 201 | DRYER FURNACE INLET AUTO DAMPER |
| XCV 1008 | 201 | DRYER FURNACE OUTLET AUTO DAMPER |
| XCV 1009 | 202 | INERT GAS SOL POSN CONT VLV |
| XCV 1010 | 202 | QUENCHED FLUE GAS POSN CONT VLV |
| XCV 1011 | 202 | QUENCHED FLUE GAS POSN CONT VLV |
| XCV 1012 | 202 | FURNACE PILOT FUEL GAS SOL CONT VLV |
| XCV 1013 | 201 | LIGNITE SURGE BIN INLET CONTROL VALVE |
| XCV 1037 | 201 | WILLIAMS MILL LIGNITE SLURR RECYCLE LINE CONTROL VALVE |
| XCV 1038 | 201 | DOLOMITE FINES BIN OUTLET CONTROL VALVE |
| XCV 1039 | 201 | DOLOMITE BIN OUTLET CONTROL VALVE |
| XCV 1041 | 202 | FURNACE FUEL GAS CONT SOL VLV |
| XCV 1042 | 202 | PNEUMATIC CONT LOOP SOL CONT VLV |
| XCV 1044 | 202 | INERT GAS POSN CONT VLV |
| XCV 1045 | 201 | DRY LIGNITE FEEDER INERT GAS SUPPLY SOLENOID VALVE |
| XCV 1048 | 202 | IGNITOR AIR LINE SOL VLV |
| XCV 1050 | 201 | DRY LIGNITE FEEDER A INERT GAS SUPPLY SOLENOID VALVE |
| XCV 1052 | 201 | LIGNITE CYCLONE INLET INERT GAS SUPPLY CONTROL VALVE |
| XCV 1052A | 201 | BAG HOUSE INERT GAS INLET CONTROL VALVE |
| XCV 1056 | 201 | DRYER FURNACE COOLING WATER SUPPLY SOLENOID VALVE |
| XCV 1059 | 201 | BAG HOUSE COOLING WATER SUPPLY SOLENOID VALVE |
| XCV 2004 | 203-1 | DOLOMITE DUMP INLET CONTROL VALVE |
| XCV 2010 | 203-1 | SPENT DOLOMITE DSCH LINE SOLENOID CONTROLLED VALVE |
| XCV 2013 | 203-1 | GASIFIER CHAR DSCH SOLENOID CONTROLLED VALVE |
| XCV 2022 | 204-1 | AIR HEATER INLET AIR SOL POSITION CONT VLV |
| XCV 2023 | 204-1 | CHAR LIFT HEATER RECYCLE GAS INLT SOL VLV |
| XCV 2024 | 204-2 | RECYCLE GAS 2 SOL POS CONT VLV |
| XCV 2026 | 204-2 | RECYCLE GAS 1 SOL POS CONT VLV |
| XCV 2039 | 202 | LIGNITE HOPPER DSCH SOL POS VLV |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XCV 2041 | 204-1 | DOLOMITE LIFT HTR LIFT GAS INLT SOL POS CONTROL VLV |
| XCV 2049 | 203-3 | DV JACKET WTR CIRC PUMP DSCH SOL CONT VLV |
| XCV 2050 | 203-3 | DV JACKET WATER CIRC PUMP SUCTION SOL VLV |
| XCV 2051 | 203-3 | GASIFIER JACKET WATER CIRC PUMPS DSCH SOL VLV |
| XCV 2052 | 203-3 | GASIFIER JACKET WATER CIRC PUMPS SUCT SOL VLV |
| XCV 2059B | 205 | ASH OUT HOPPER A OUTL CONT VLV |
| XCV 2060B | 205 | ASH OUT HOPPER B OUTL CONT VLV |
| XCV 2073 | 203-1 | WASTE DOLOMITE POSITION CONTROL VALVE |
| XCV 2085 | 202 | LIGNITE HOPPER INLT ELEC POSN CONT VLV |
| XCV 2086 | 202 | LIGNITE IN HOPPER B INLET CONTROL VALVE |
| XCV 2087 | 202 | LIGNITE HOPPER PURGE GAS ELEC POSN CONT VLV |
| XCV 2088 | 202 | LIGNITE IN HOPPER B CO2 INLET CONTROL VALVE |
| XCV 2090 | 202 | LIG FDR B DSCH SOLENOID POSN VLV |
| XCV 2095 | 202 | LIGNITE HOPPER EQUALIZING VNT POSN CONT VLV |
| XCV 2096 | 202 | LIGNITE IN HOPPER B VENT GAS CONTROL VALVE |
| XCV 2097 | 205 | ASH OUT HOPPER A RELIEF VENT GAS CONTROL VALVE |
| XCV 2098 | 205 | ASH OUT HOPPER B RELIEF VENT GAS CONTROL VALVE |
| XCV 2119 | 204-1 | AIR HEATER INLET INERT GAS SOL POS CONT VLV |
| XCV 2120 | 202 | QUENCHED FUEL GAS AUTO/MAN CONT VLV |
| XCV 2126 | 204-2 | DV CYCLE COMP SOL CONT VLV |
| XCV 2127 | 203-1 | DEVOLATILIZER PROCESS GAS SOLENOID CONTROL VALVE |
| XCV 2128 | 203-1 | PURGE GAS CONTROL SOLENOID VALVE |
| XCV 2129 | 203-1 | DEVOLATILIZER SPENT DOLOMITE DSCH SOLENOID VALVE |
| XCV 2130 | 203-1 | DOLOMITE SUPPLY SOLENOID CONTROL VALVE |
| XCV 2131 | 203-1 | COKE DISCHARGE LINE SOLENOID VALVE |
| XCV 2132 | 203-1 | GASIFIER SPENT DOLOMITE LINE SOLENOID VALVE |
| XCV 2150 | 205 | ASH OUT HOPPER A INERT GAS INLET CONT VLV |
| XCV 2151 | 205 | ASH OUT HOPPER B INERT GAS INLT CONTROL VALVE |
| XCV 3002 | 207 | WASTE GAS TO FLARE PRESS CONT VLV SOLENOID VLV<br>STD DEVICE OK |
| XCV 5069 | 208 | FIRST STAGE RECYCLE CO2 CMPR FUEL GAS INLT CONT VLV<br>STD VENDOR FURNISHED CONTROL |
| XHC 1003 | 201 | DRYER FURNACE INLET AUTO DAMPER HAND CONTROLLER |
| XHC 1010 | 202 | QUENCHED FLUE GAS CV HAND POSN CONT |
| XHC 1011 | 202 | QUENCHED FLUE GAS CV HAND POSN CONT |
| XHC 1037 | 201 | WILLIAMS MILL LIGNITE SLURRY CONT VALVE HAND CONTROL |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XHC 1038 | 201 | DOLOMITE FINES BIN OUTLET CONTROL VALVE HAND CONTROLLER |
| XHC 1039 | 201 | DOLOMITE BIN OUTLET CONTROL VALVE HAND CONTROLLER |
| XHC 2073 | 203-1 | WASTE DOLOMITE VALVE HAND POSITION CONTROL |
| XHC 2150 | 205 | ASH OUT HOPPER A INERT GAS INLT CV HAND CONTROLLER |
| XHC 2151 | 205 | ASH OUT HOPPER B INERT GAS INLT CV HAND CONTROLLER |
| XXH 2134 | 204-1 | MAIN AIR COMPPESSOR VIBRATION LVL HI |
| X1008U | 204-2 | 8 UNLISTED PRESS IND |
| ZI 1002 | 201 | DRYER FURNACE START-UP STACK AUTO DAMPER POSITION INDICATOR |
| ZI 1008 | 201 | DRYER FURNACE OUTLET AUTO DAMPER POSITION INDICATOR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE HYGAS PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET IGT | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AIC 510 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL IND CONT |
| AIC 521 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL IND CONT |
| AIT 510 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL RCDR |
| AR 405 | 4.00-1-J | QUENCH TOWER GAS ANALYTICAL RCDR |
| AR 406 | 4.00-1-J | HYGAS ANALYTICAL RCDR |
| AR 462 | 4.00-2-J | CAUSTIC & WATER WASH SCRUBBER GAS ANALYSIS RCDR CO |
| AR 463 | 4.00-2-J | CAUSTIC & WATER WASH SCRUBBER CO2 ANALYTICAL RCDR |
| AR 505 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL RCDR |
| AR 510 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL RCDR |
| AR 521 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL RCDR |
| AR 566 | 5.00-1-J | 1ST STAGE QUENCH GAS H2 ANALYTICAL RCDR |
| AY 510 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL E/P CNVTR |
| AY 521 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL E/P CNVTR |
| EL 115 | 1.00-1-J | UNTREATED COAL FLOW VALVE PILOT LIGHT |
| EL 309 | 3.00-1-J | FEED SLURRY PUMP MOTOR PILOT LIGHT |
| EMF/P 321 | 3.00-2-J | HYGAS REACTOR LEVEL E/P CNVTR |
| FE 511 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW ELMT |
| FE 522 | 5.00-1-J | RECYCLE GAS FLOW ELMT |
| FI 3038 | 3.00-1-J | FEED SLURRY PUMP LIGHT OIL SUPPLY FLOW INDICATOR STD DEVICE |
| FI 3144 | 3.00-2-J | HYGAS REACTOR IN-LINE FLOW INDICATOR |
| FI 3145 | 3.00-2-J | HYGAS REACTOR IN-LINE FLOW INDICATOR |
| FIC 511 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW IND CONT |
| FIC 522 | 5.00-1-J | 1ST STAGE QUENCH GAS IND FLOW CONT |
| FR 3079 | 3.00-1-J | FEED SLURRY PUMPS SUCTION FLOW REC |
| FR 506 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW RECORDER RCDR OK BUT NO PRESSURE CORRECTION |
| FR 511 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW RCDR |
| FR 522 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW RCDR |
| FT 506 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW RCDR |
| FT 511 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW XMTR |
| FT 522 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW TRANSMITTER |
| FV 2022 | 1.00-1-J | COAL FLOW VALVE |
| FV 511 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW CONT VALVE |
| FV 522 | 5.00-1-7 | 1ST STAGE QUENCH GAS FLOW CONT VALVE |
| FY 511 | 5.00-1-J | 1ST STAGE QUENCH GAS FLOW SQ RT CNVTR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE HYGAS PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET IGT | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FY 522 | 5.00-1-J | 1ST STAGE QUENCH GAS SQ RT CNVTR |
| HS 112 | 1.00-1-J | COAL WEIGHT INTIGRATOR HAND SWITCH |
| HSB 315A | 3.00-1-J | FEED SLURRY PUMP MOTOR BOARD MOUNTED HAND SWITCH |
| HSL 315A | 3.00-1-J | FEED SLURRY PUMP MOTOR LOCAL HAND SWITCH |
| IE 309 | 3.00-1-J | FEED SLURRY PUMP MOTOR CURRENT XFRMR |
| II 309 | 3.00-1-J | FEED SLURRY PUMP MOTOR CURRENT IND |
| LIC 321 | 3.00-2-J | HYGAS REACTOR LEVEL IND CONT |
| LR 321 | 3.00-2-J | HYGAS REACTOR LEVEL RECORDER |
| LT 321A | 3.00-2-J | HYGAS REACTOR LEVEL TRANSMITTER A |
| LVZ 321 | 3.00-2-J | HYGAS REACTOR CHAR LINE LEVEL VALVE DRIVE |
| PDR 3089 | 3.00-2-J | HYGAS REACTOR D/P RECORDER |
| PDR 374 | 3.00-2-J | HYGAS REACTOR D/P RECORDER |
| PI 3144 | 3.00-2-J | HYGAS REACTOR PRESSURE IND |
| PI 3145 | 3.00-2-J | HYGAS REACTOR PRESSURE INDICATOR |
| PI 533 | 5.00-1-J | 1ST STAGE QUENCH GAS ANZR INLT PRESSURE IND |
| PV 523 | 5.00-1-J | 1ST STAGE QUENCH GAS D/P CONT VLV |
| WR 112 | 1.00-1-J | COAL WEIGHT RECORDER |
| XA 1002 | 3.00-2-J | 2 UNLISTED ANALYSIS DEVICES |
| XD 1001A | 61-D | 1 UNLISTED DIFF PRESSURE DEVICE |
| XD 1001B | 7.00-1-J | 1 UNLISTED DIFF PRESSURE DEVICE |
| XD 1003 | 50-35-E | 3 UNLISTED DIFFL PRESSURE DEVICES |
| XD 1004A | 4.00-2-J | 4 UNLISTED DIFF PRESSURE DEVICES |
| XD 1004B | 4.00-3-J | 4 UNLISTED DIFF PRESSURE DEVICES |
| XD 1004C | 6.00-2-J | 4 UNLISTED DENSITY DEVICES |
| XD 1005A | 2.00-2-J | 5 UNLISTED DIFF PRESSURE DEVICES |
| XD 1005B | 5.00-1-J | 5 UNLISTED DIFF PRESSURE DEVICES |
| XD 1006 | 1.00-1-J | 6 UNLISTED DIFF PRESSURE DEVICES |
| XD 1007 | 2.00-1-J | 7 UNLISTED DIFF PRESSURE DEVICES |
| XD 1026 | 3.00-2-J | 26 UNLISTED DIFFL PRESSURE DEVICES |
| XD 1043 | 3.00-2-J | 43 UNLISTED DIFFL PRESSURE DEVICES |
| XE 1001 | 3.00-2-J | 1 UNLISTED ELECTRICAL DEVICES |
| XE 1007 | 50-35-E | 7 UNLISTED ELEC DEVICES |
| XE 1009A | 61-D | 9 UNLISTED ELECTRICAL DEVICES |
| XE 1009B | 4.00-1-J | 9 UNLISTED ELEC DEVICES |
| XE 1011 | 4.00-2-J | 11 UNLISTED ELEC DEVICES |
| XE 1014A | 3.00-1-J | 14 UNLISTED ELECTRICAL DEVICES |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE HYGAS PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET IGT | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XE 1014B | 4.00-3-J | 14 UNLISTED ELEC DEVICES |
| XE 1015 | 2.00-1-J | 15 UNLISTED ELECTRICAL DEVICES |
| XE 1020A | 3.00-3-J | 20 UNLISTED ELEC DEVICES |
| XE 1020B | 6.00-2-J | 20 UNLISTED ELEC DEVICES |
| XE 1025 | 6.00-1-J | 25 UNLISTED ELEC DEVICES |
| XE 1036 | 2.00-2-J | 36 UNLISTED ELECTRICAL DEVICES |
| XE 1046 | 1.00-1-J | 46 UNLISTED ELECTRICAL DEVICES |
| XE 1063 | 7.00-1-J | 63 UNLISTED ELEC DEVICES |
| XF 1001 | 6.00-2-J | 1 UNLISTED FLOW DEVICE |
| XF 1006 | 6.00-1-J | 6 UNLISTED FLOW DEVICES |
| XF 1009 | 4.00-2-J | 9 UNLISTED FLOW DEVICES |
| XF 1013 | 1.00-1-J | 13 UNLISTED FLOW DEVICES |
| XF 1019A | 2.00-2-J | 19 UNLISTED FLOW DEVICES |
| XF 1019B | 4.00-1-J | 19 UNLISTED FLOW DEVICES |
| XF 1020 | 61-D | 20 UNLISTED FLOW DEVICES |
| XF 1022 | 5.00-1-J | 22 UNLISTED FLOW DEVICES |
| XF 1023 | 7.00-1-J | 23 UNLISTED FLOW DEVICES |
| XF 1024 | 4.00-3-J | 24 UNLISTED FLOW DEVICES |
| XF 1027 | 3.00-3-J | 27 UNLISTED FLOW DEVICES |
| XF 1043 | 50-35-E | 43 UNLISTED FLOW DEVICES |
| XF 1051 | 2.00-1-J | 51 UNLISTED FLOW DEVICES |
| XF 1065 | 3.00-2-J | 65 UNLISTED FLOW DEVICES |
| XF 1067 | 3.00-2-J | 67 UNLISTED FLOW DEVICES |
| XH 1009 | 3.00-2-J | 9 UNLISTED HAND DEVICES |
| XH 1012 | 3.00-2-J | 12 UNLISTED HAND DEVICES |
| XH 1022 | 3.00-1-J | 22 UNLISTED HAND DEVICES |
| XI 1002 | 6.00-2-J | 2 UNLISTED ALARM DEVICES |
| XI 1003A | 3.00-1-J | 3 UNLISTED ALARM DEVICES |
| XI 1003B | 4.00-2-J | 3 UNLISTED ALARM DEVICES |
| XI 1003C | 4.00-3-J | 3 UNLISTED ALARM DEVICES |
| XI 1005A | 1.00-1-J | 5 UNLISTED ALARM DEVICES |
| XI 1005B | 3.00-3-J | 5 UNLISTED ALARM DEVICES |
| XI 1006 | 50-35-E | 6 UNLISTED ALARM DEVICES |
| XI 1006A | 2.00-2-J | 6 UNLISTED ALARM DEVICES |
| XI 1006B | 5.00-1-J | 6 UNLISTED ALARM DEVICES |
| XI 1007 | 4.00-1-J | 7 UNLISTED ALARM DEVICES |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE HYGAS PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET IGT | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XI 1008A | 61-D | 8 UNLISTED ALARM DEVICES |
| XI 1008B | 2.00-1-J | 8 UNLISTED ALARM DEVICES |
| XI 1009 | 3.00-2-J | 9 UNLISTED ALARM DEVICES |
| XI 1010 | 7.00-1-J | 10 UNLISTED ALARM DEVICES |
| XI 1012 | 3.00-2-J | 12 UNLISTED ALARM DEVICES |
| XL 1003 | 7.00-1-J | 3 UNLISTED LEVEL DEVICES |
| XL 1007A | 1.00-1-J | 7 UNLISTED LEVEL DEVICES |
| XL 1007B | 5.00-1-J | 7 UNLISTED FLOW DEVICES |
| XL 1008A | 3.00-1-J | 8 UNLISTED LEVEL DEVICES |
| XL 1008B | 6.00-2-J | 8 UNLISTED LEVEL DEVICES |
| XL 1009A | 2.00-1-J | 9 UNLISTED LEVEL DEVICES |
| XL 1009B | 3.00-2-J | 9 UNLISTED LEVEL DEVICES |
| XL 1013 | 4.00-3-J | 13 UNLISTED LEVEL DEVICES |
| XL 1014 | 6.00-1-J | 14 UNLISTED LEVEL DEVICES |
| XL 1018 | 2.00-2-J | 18 UNLISTED LEVEL DEVICES |
| XL 1019 | 3.00-2-J | 19 UNLISTED LEVEL DEVICES |
| XL 1022 | 4.00-2-J | 22 UNLISTED LEVEL DEVICES |
| XL 1024 | 50-35-E | 24 UNLISTED LEVEL DEVICES |
| XL 1024A | 61-D | 24 UNLISTED LEVEL DEVICES |
| XL 1025 | 3.00-3-J | 25 UNLISTED LEVEL DEVICES |
| XP 1003 | 1.00-1-J | 3 UNLISTED PRESSURE DEVICES |
| XP 1009 | 2.00-2-J | 9 UNLISTED PRESSURE DEVICES |
| XP 1011 | 3.00-3-J | 11 UNLISTED PRESSURE DEVICES |
| XP 1013 | 3.00-1-J | 13 UNLISTED PRESSURE DEVICES |
| XP 1014A | 61-D | 14 UNLISTED PRESSURE DEVICES |
| XP 1014B | 4.00-2-J | 14 UNLISTED PRESSURE DEVICES |
| XP 1014C | 6.00-2-J | 14 UNLISTED PRESSURE DEVICES |
| XP 1018 | 4.00-1-J | 18 UNLISTED PRESSURE DEVICES |
| XP 1020 | 4.00-3-J | 20 UNLISTED PRESSURE DEVICES |
| XP 1024 | 50-35-E | 24 UNLISTED PRESSURE DEVICES |
| XP 1028 | 6.00-1-J | 28 UNLISTED PRESSURE DEVICES |
| XP 1030 | 5.00-1-J | 30 UNLISTED PRESSURE DEVICES |
| XP 1036 | 2.00-1-J | 36 UNLISTED PRESSURE DEVICES |
| XP 1039 | 3.00-2-J | 39 UNLISTED PRESSURE DEVICES |
| XP 1041 | 3.00-2-J | 41 UNLISTED PRESSURE DEVICES |
| XP 1045 | 7.00-1-J | 45 UNLISTED PRESSURE DEVICES |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE HYGAS PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET IGT | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XT 1006 | 6.00-1-J | 6 UNLISTED TEMPERATURE DEVICES |
| XT 1010 | 1.00-1-J | 10 UNLISTED TEMPERATURE DEVICES |
| XT 1011 | 6.00-2-J | 11 UNLISTED TEMPERATURE DEVICES |
| XT 1012 | 3.00-1-J | 12 UNLISTED TEMPERATURE DEVICES |
| XT 1013 | 2.00-2-J | 13 UNLISTED TEMPERATURE DEVICES |
| XT 1014 | 3.00-3-J | 14 UNLISTED TEMPERATURE DEVICES |
| XT 1015A | 61-D | 15 UNLISTED TEMPERATURE DEVICES |
| XT 1015B | 4.00-3-J | 15 UNLISTED TEMPERATURE DEVICES |
| XT 1018 | 4.00-1-J | 18 UNLISTED TEMPERATURE DEVICES |
| XT 1024 | 4.00-2-J | 24 UNLISTED TEMPERATURE DEVICES |
| XT 1026 | 50-35-E | 26 UNLISTED TEMPERATURE DEVICES |
| XT 1037A | 2.00-1-J | 37 UNLISTED TEMPERATURE DEVICES |
| XT 1037B | 3.00-2-J | 37 UNLISTED TEMPERATURE DEVICES |
| XT 1043 | 5.00-1-J | 43 UNLISTED TEMPERATURE DEVICES |
| XT 1044 | 7.00-1-J | 44 UNLISTED TEMPERATURE DEVICES |
| XT 1054 | 3.00-2-J | 54 UNLISTED TEMPERATURE DEVICES |
| XZ 1001 | 3.00-2-J | 1 UNLISTED POSITION DEVICE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| A 105 | P3-4 | SLURRY PREHEATER OUTLET TEMP ALARM |
| A 161 | P3-10 | FLTR A CAKE HOPPER HI LVL TRIP UNIT |
| A 162 | P3-10 | FLTR B CAKE HOPPER HI LVL TRIP UNIT |
| A 166A | P3-5 | HP FLASH DRUM SLURRY HI LVL TRIP UNIT A |
| A 166B | P3-5 | HP FLASH DRUM SLURRY HI LVL TRIP UNIT B |
| A 169 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL HI PRESS T/U |
| A 172 | P3-5 | RECYCLE CONDENSATE SEPARATOR HI/LO LEVEL TRIP UNIT |
| A 175 | P3-5 | INT P FLASH DRUM HI LEVEL TRIP UNIT |
| A 2263 | P3-6 | FLASH COND SEPARATOR 1 HI LVL TRIP UNIT |
| A 2264 | P3-6 | FLASH COND SEPARATOR 2 HI LVL TRIP UNIT |
| A 2287 | P3-4 | SLURRY PREHEATER INLET TEMPERATURE ALARM |
| A 30 | P3-6 | FILTER FEED FLASH VSL HI/LO LVL TRIP UNIT |
| A 34 | P3-7 | PRECOAT SLURRY PRESS VSL HI LVL TRIP UNIT |
| A 37 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY HI LVL TRIP UNIT |
| A 42 | P3-7 | PRECOAT ROTARY DRUM FLTR B HI LVL TRIP UNIT |
| A 709 | P3-5 | HP FLASH DRUM VAPOR HI TEMP TRIP UNIT |
| A 85 | P3-4 | SLURRY PREHEATER HYDROGE/SYNTHESIS GAS INLET FLOW ALARM |
| A 88 | P3-4 | SLURRY PREHEATER INLET PRESSURE ALARM |
| AN 175 | P3-5 | INT P FLASH DRUM SLURRY HI LEVEL ANNUNC |
| AN 703 | P3-5 | HP FLASH DRUM SLURRY HI LVL ANNUNC |
| AN 704 | P3-5 | HP FLASH DRUM SLURRY HI LVL ANNUNC |
| AN 706 | P3-5 | RECYCLE CONDENSATE SEPARATOR HI/LO LEVEL ANNUNC |
| AN 707 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL HI PRESS ANNUN |
| AN 755 | P3-5 | HP FLASH DRUM VAPOR HI TEMP ANNUNC |
| AN 774 | P3-6 | FILTER FEED FLASH VSL HI LVL ANNUNC |
| AN 775 | P3-6 | FILTER FEED FLASH VSL LO LVL ANNUNC |
| AN 807 | P3-6 | FLASH COND SEPARATOR 1 HI LVL ANNUNC |
| AN 808 | P3-6 | FLASH COND SEPARATOR 2 HI LVL ANNUNC |
| CD 105 | P3-4 | SLURRY PREHEATER OUTLET TEMP SIGNAL CNVTR |
| CD 158 | P3-5 | RECYCLE COND SEPARATOR LIQ HYDROCARBONS OUTL FLOW SIGNAL CON |
| CD 161 | P3-10 | FLTR A CAKE HOPPER LVL SIGNAL CONV |
| CD 162 | P3-10 | FLTR B CAKE HOPPER LVL SIGNAL CONV |
| CD 167 | P3-5 | HP FLASH DRUM SLURRY TEMP SIGNAL CONVERTER |
| CD 170A | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL FLOW SQ RT EXT |
| CD 170B | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL FLOW COMP DEV |
| CD 174 | P3-5 | INT P FLASH DRUM VAPOR OUTL FLOW SIGNAL CONVERTER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| CD 2117 | P3-6 | FLASH COND SEPARATORS HYDROCARBON VAPOR OUTL FLOW SQ RT EXTR |
| CD 2239 | P3-7 | PRECOAT ROTARY DRUM FLTR A SPEED SIGNAL CONV |
| CD 2241 | P3-7 | PRECOAT ROTARY DRUM FLTR B SPEED SIGNAL CONV |
| CD 2287 | P3-4 | SLURRY PREHEATER INLET TEMPERATURE SIGNAL CONVERTER |
| CD 298 | P3-7 | PRECOAT ROTARY DRUM FLTR A HYDROCARBON VAPOR INLT PRESS S/CV |
| CD 299 | P3-7 | PRECOAT ROTARY DRUM FLTR B HYDROCARBON VAPOR INLT PRESS S/CV |
| CD 32 | P3-6 | FILTER FEED FLASH VSL TEMP SIGNAL CONVERTER |
| CD 33 | P3-7 | PRECOAT SLURRY PRESS VSL TEMP SIGNAL CONV |
| CD 36 | P3-7 | FILTER SOLVENT SPLY EXGR A INLT FLOW SQ RT EXTRACTOR |
| CD 40 | P3-7 | FILTER SOLVENT SPLY EXGR A OUTL TEMP SIGNAL CONV |
| CD 41 | P3-7 | FILTER SOLVENT SPLY EXGR B INLT FLOW SQ RT EXTRACTOR |
| CD 45 | P3-7 | FILTER SOLVENT SPLY EXGR B OUTL TEMP SIGNAL CONV |
| CD 709 | P3-5 | HP FLASH DRUM VAPOR TEMP SIGNAL CONVERTER |
| CD 85A | P3-4 | SLURRY PREHEATER HYDROGEN/SYNTHESIS GAS INL FLOW CONVERTER |
| CD 85B | P3-4 | SLURRY PREHEATER HYDROGEN/SYNTHESIS GAS INL FLOW CONVERTER |
| DPS 2295 | P3-10 | DRYER EXHAUST BLOWER SUCT/DSCH DIFFL PRESS SW |
| DPT 2295 | P3-10 | DRYER EXHAUST BLOWER SUCT/DSCH DIFFL PRESS XMTR |
| E/P 164 | P3-10 | DRYER CONDENSATE DRUM LVL CONT VLV SIGNAL CONV |
| E/P 166 | P3-5 | HP FLASH DRUM SLURRY LEVEL CONT VLV SIGNAL CONVERTER |
| E/P 167 | P3-5 | DISSOLVER PRODUCT AIR COOLED EXGR AIR FLOW CONT DAMPER E/P |
| E/P 169 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL PCV SIGNAL CON |
| E/P 172 | P3-5 | RECYCLE CONDENSATE SEPARATOR LVL CONT VLV SIGNAL CONVERTER |
| E/P 173 | P3-5 | INT P FLASH DRUM VAPOR OUTL PRESS CONT VLV SIGNAL CONVERTER |
| E/P 175 | P3-5 | INT P FLASH DRUM SLURRY LEVEL CONT VLV SIGNAL CONVERTER |
| E/P 181 | P3-6 | FILTER FEED SURGE VSL LVL CONT VLV SIGNAL CONVERTER |
| E/P 182A | P3-6 | FILTER FEED SURGE VSL HYDROCARBON VAPOR OUTL PCV SIGNAL CONV |
| E/P 182B | P3-6 | FILTER FEED SURGE VSL INERT GAS INLT PCV SIGNAL CONVERTER |
| E/P 187 | P3-6 | FILTER FEED FLASH RCIRC EXGR LIQ HYDROCARBONS INLT PCV S/CV |
| E/P 2195 | P3-6 | FLASH COND SEPARATORS HYDROCARBON VAPOR OUTL PCV SIGNAL CONV |
| E/P 2263 | P3-6 | FLASH COND SEPARATOR 1 LVL CONT VLV SIGNAL CONVERTER |
| E/P 2264 | P3-6 | FLASH COND SEPARATOR 2 LVL CONT VLV SIGNAL CONVERTER |
| E/P 2268 | P3-6 | RECYCLE PROCESS WTR TNK LVL CONT VLV SIGNAL CONVERTER |
| E/P 2310 | P3-10 | DRYER CONDENSATE COOLER OUTL TEMP CONT VLV SIGNAL CONV |
| E/P 28 | P3-6 | FILTER FEED FLASH VSL HYDROCARBON VAPOR OUTL PCV SIGNAL CONV |
| E/P 30 | P3-6 | FILTER FEED FLASH VSL LVL CONT VLV SIGNAL CONVERTER |
| E/P 32 | P3-6 | FILTER FEED FLASH VSL TEMP CONT VLV SIGNAL CONVERTER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| E/P 33 | P3-7 | PRECOAT SLURRY PRESS VSL TEMP CONT VLV SIGNAL CONV |
| E/P 34 | P3-7 | PRECOAT SLURRY PRESS VSL LVL CONT VLV SIGNAL CONV |
| E/P 36 | P3-7 | FILTER SOLVENT SPLY EXGR A INLT FLOW CONT VLV SIGNAL CONV |
| E/P 37 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY LVL CONT VLV SIGNAL CONV |
| E/P 39 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY INLT FLOW CONT VLV S/CV |
| E/P 40 | P3-7 | FILTER SOLVENT SPLY EXGR A OUTL TEMP CONT VLV SIGNAL CONV |
| E/P 41 | P3-7 | FILTER SOLVENT SPLY EXGR B INLT FLOW CONT VLV SIGNAL CONV |
| E/P 42 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURR LVL CONT VLV SIGNAL CONV |
| E/P 44 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY INLT FLOW CONT VLV S/CV |
| E/P 45 | P3-7 | FILTER SOLVENT SPLY EXGR B OUTL TEMP CONT VLV SIGNAL CONV |
| E/P 85 | P3-4 | SLURRY PREHEATER HYDROGEN/SYNTHESIS E/P CONVERTER |
| FC 187 | P3-6 | FILTER FEED FLASH RCIRC EXGR LIQ HYDROCARBONS INLT FLOW CONT |
| FC 36 | P3-7 | FILTER SOLVENT SPLY EXGR A INLT FLOW CONT |
| FC 38 | P3-7 | PRECOAT ROTARY DRUM FILTER A INERT GAS SPLY FLOW CONT |
| FC 39 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY INLT FLOW CONT |
| FC 41 | P3-7 | FILTER SOLVENT SPLY EXGR B INLT FLOW CONT |
| FC 43 | P3-7 | PRECOAT ROTARY DRUM FLTR B INERT GAS SPLY FLOW CONT |
| FC 44 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY INLT FLOW CONT |
| FC 85 | P3-4 | SLURRY PREHEATER HYDROGEN/SYNTHESIS GAS INLET FC |
| FI 166A | P3-5 | HP FLASH DRUM SLURRY HYDROGEN/SYNTHESIS GAS PURGE FLOW IND |
| FI 166B | P3-5 | HP FLASH DRUM VAPOR HYDROGEN/SYNTHESIS GAS PURGE FLOW IND |
| FI 166C | P3-5 | HP FLASH DRUM VAPOR HYDROGEN/SYNTHESIS GAS PURGE FLOW IND |
| FI 166D | P3-5 | HP FLASH DRUM SLURRY HYDROGEN/SYNTHESIS GAS PURGE FLOW IND |
| FI 175A | P3-5 | INT P FLASH DRUM VAPOR HYDROGEN/SYNTHESIS GAS PURGE FLOW IND |
| FI 175B | P3-5 | INT P FLASH DRUM SLURRY HYDROGEN/SYNTHESIS GAS PURGE FLO IND |
| FI 34A | P3-7 | PRECOAT SLURRY LVL XMTR LT-34 HP LEG INERT GAS PRG FLOW IND |
| FI 34B | P3-7 | PRECOAT SLURRY LVL XMTR LT-34 LP LEG INERT GAS PRG FLOW IND |
| FI 37A | P3-7 | SLURRY LVL XMTR LT-37 HI PRESS LEG INERT GAS PURGE FLOW IND |
| FI 37B | P3-7 | SLURRY LVL XMTR LT-37 LO PRESS LEG INERT GAS PURGE FLOW IND |
| FI 416 | P3-7 | PRECOAT ATMOS MIX TNK SLURRY INLT FLOW IND |
| FI 417 | P3-7 | PRECOAT SLURRY DSCH PMP DSCH FLOW IND |
| FI 42A | P3-7 | SLURRY LVL XMTR LT-42 HI PRESS LEG INERT GAS PURGE FLOW IND |
| FI 42B | P3-7 | PRECOAT ROTARY DRUM FLTR B ASH OUTL LIQ HYDROCARBONS SPLY FI |
| FI 428 | P3-7 | PRECOAT ROTARY DRUM FLTR A ASH OUTL LIQ HYDROCARBONS SPLY FI |
| FI 454 | P3-10 | MINERAL RESIDUE COOLER CLG WTR SPLY FLOW IND |
| FI 457 | P3-10 | DRYER CONDENSATE DRUM PURGE FLOW IND |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FI 470A | P3-10 | DRYER CONDENSATE DRUM PURGE FLOW IND |
| FI 470B | P3-10 | DRYER CONDENSATE DRUM PURGE FLOW IND |
| FI 743 | P3-10 | DRYER CONDENSATE DRUM PURGE FLOW IND |
| FQ 170 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL FLOW INTEGRATR |
| FQ 2117 | P3-6 | FLASH COND SEPARATORS HYDROCARBON VAPOR OUTL FLOW INTEGRATOR |
| FQ 36 | P3-7 | FILTER SOLVENT SPLY EXGR A INLT FLOW INTEGRATOR |
| FQ 41 | P3-7 | FILTER SOLVENT SPLY EXGR B INLT FLOW INTEGRATOR |
| FQ 85 | P3-4 | SLURRY PREHEATER HYDROGEN/SYNTHESIS GAS INL FLOW INTEGRATOR |
| FT 157 | P3-5 | INT P FLASH DRUM SLURRY OUTL FLOW XMTR |
| FT 158 | P3-5 | RECYCLE CONDENSATE SEPARATOR LIQ HYDROCARBONS OUTL FLOW XMTR |
| FT 170 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL FLOW XMTR |
| FT 174 | P3-5 | INT P FLASH DRUM VAPOR OUTL FLOW XMTR |
| FT 187 | P3-6 | FILTER FEED FLASH RCIRC EXGR LIQ HYDROCARBONS INLT FLOW XMTR |
| FT 2117 | P3-6 | FLASH COND SEPARATORS HYDROCARBON VAPOR OUTL FLOW XMTR |
| FT 2121 | P3-10 | DRYER EXHAUST BLOWER DSCH FLOW XMTR |
| FT 2199 | P3-6 | FLASH COND SEPARATOR 1 LIQ HYDROCARBONS OUTL FLOW XMTR |
| FT 2275 | P3-6 | FLASH COND SEPARATOR 2 PROCESS WST OUTL FLOW XMTR |
| FT 2316 | P3-6 | WATER BOOSTER PMP DISCH FLOW XMTR |
| FT 35 | P3-4 | SLURRY PREHEATER HYDROGEN/SYNTHESIS GAS INLET FT |
| FT 36 | P3-7 | FILTER SOLVENT SPLY EXGR A INLT FLOW XMTR |
| FT 38 | P3-7 | PRECOAT ROTARY DRUM FILTER A INERT GAS SPLY FLOW XMTR |
| FT 39 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY INLT FLOW XMTR |
| FT 41 | P3-7 | FILTER SOLVENT SPLY EXGR B INLT FLOW XMTR |
| FT 43 | P3-7 | PRECOAT ROTARY DRUM FLTR B INERT GAS SPLY FLOW XMTR |
| FT 44 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY INLT FLOW XMTR |
| FT 47 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY OUTL FLOW XMTR |
| FT 49 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY OUTL FLOW XMTR |
| HIC 166 | P3-5 | HP FLASH DRUM LVL XMTR A/B OUTPUT SEL SW |
| HIC 2115 | P3-7 | PRECOAT ATMOS MIX TNK DSCH PMP VAR SPEED DRIVE HAND IND CONT |
| HIC 2236 | P3-7 | PRECOAT SLURRY DSCH PMP VARIABLE SPEED DRIVE HAND IND CONT |
| HIC 2319 | P3-7 | PRECOAT SOLVENT CLR PRESS CONT DMPR HAND IND CONT |
| LC 161 | P3-10 | FLTR A CAKE HOPPER LVL CONT |
| LC 162 | P3-10 | FLTR B CAKE HOPPER LVL CONT |
| LC 166 | P3-5 | HP FLASH DRUM SLURRY LEVEL CONT |
| LC 172 | P3-5 | RECYCLE CONDENSATE SEPARATOR LEVEL CONT |
| LC 175 | P3-5 | INT P FLASH DRUM SLURRY LEVEL CONT |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LC 181 | P3-6 | FILTER FEED SURGE VSL LVL CONT |
| LC 2170 | P3-7 | PRECOAT ATMOS MIX TNK SLURRY LVL CONT |
| LC 2203 | P3-7 | FILTER A VAPOR SURGE DRUM LIQ HYDROCARBONS LVL CONT |
| LC 2204 | P3-7 | FILTER B VAPOR SURGE DRUM LIQ HYDROCARBONS LVL CONT |
| LC 2263 | P3-6 | FLASH COND SEPARATOR 1 LEVEL CONT |
| LC 2264 | P3-6 | FLASH COND SEPARATOR 2 LVL CONT |
| LC 2265 | P3-6 | FLASH COND SEPARATOR 2 LVL CONT |
| LC 30 | P3-6 | FILTER FEED FLASH VSL LVL CONT |
| LC 34 | P3-7 | PRECOAT SLURRY PRESS VSL LVL CONT |
| LC 37 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY LVL CONT |
| LC 42 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY LVL CONT |
| LE 161 | P3-10 | FLTR A CAKE HOPPER LVL SENSOR |
| LE 162 | P3-10 | FLTR B CAKE HOPPER LVL SENSOR |
| LE 2301A | P3-10 | MINERAL RESIDUE COOLER CLG WTR LO LVL SENSOR |
| LE 2301B | P3-10 | MINERAL RESIDUE COOLER CLG WTR HI LVL SENSOR |
| LG 401 | P3-5 | RECYCLE CONDENSATE SEPARATOR LEVEL GLASS |
| LG 418 | P3-7 | FILTER A VAPOR SURGE DRUM LIQ HYDROCARBONS LVL GLASS |
| LG 419 | P3-7 | FILTER B VAPOR SURGE DRUM LIQ HYDROCARBONS LVL GLASS |
| LG 430 | P3-10 | DRYER CONDENSATE DRUM LVL GLASS |
| LG 447 | P3-6 | FLASH COND SEPARATOR 1 LVL GLASS |
| LG 448 | P3-6 | FLASH COND SEPARATOR 2 LEVEL GLASS |
| LI 166A | P3-5 | HP FLASH DRUM LEVEL IND A |
| LI 166B | P3-5 | HP FLASH DRUM LEVEL IND B |
| LIC 164 | P3-10 | DRYER CONDENSATE DRUM LVL IND CONT |
| LIC 2268 | P3-6 | RECYCLE PROCESS WTR TNK LVL IND CONT |
| LS 2322A | P3-10 | MINERAL RESIDUE BIN HI LVL SW |
| LS 2322B | P3-10 | MINERAL RESIDUE BIN LO LVL SW |
| LS 734 | P3-10 | DRYER CONDENSATE DRUM HI LVL SW |
| LS 738 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY LVL SW |
| LS 739 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY LVL SW |
| LT 161 | P3-10 | FLTR A CAKE HOPPER LVL XMTR |
| LT 162 | P3-10 | FLTR B CAKE HOPPER LVL XMTR |
| LT 164 | P3-10 | DRYER CONDENSATE DRUM LVL XMTR |
| LT 166A | P3-5 | HP FLASH DRUM SLURRY LEVEL XMTR A |
| LT 166B | P3-5 | HP FLASH DRUM SLURRY LEVEL XMTR B |
| LT 172 | P3-5 | RECYCLE CONDENSATE SEPARATOR LEVEL XMTR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LT 175 | P3-5 | INT P FLASH DRUM SLURRY LEVEL XMTR |
| LT 181 | P3-6 | FILTER FEED SURGE VSL LVL XMTR |
| LT 2170 | P3-7 | PRECOAT ATMOS MIX TNK SLURRY LVL XMTR |
| LT 2203 | P3-7 | FILTER A VAPOR SURGE DRUM LIQ HYDROCARBONS LVL XMTR |
| LT 2204 | P3-7 | FILTER B VAPOR SURGE DRUM LIQ HYDROCARBONS LVL XMTR |
| LT 2263 | P3-6 | FLASH COND SEPARATOR 1 LEVEL XMTR |
| LT 2264 | P3-6 | FLASH COND SEPARATOR 2 LEVEL XMTR |
| LT 2268 | P3-6 | RECYCLE PROCESS WTR TNK LEVEL XMTR |
| LT 30 | P3-6 | FILTER FEED FLASH VSL LVL XMTR |
| LT 34 | P3-7 | PRECOAT SLURRY PRESS VSL LVL XMTR |
| LT 37 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY LVL XMTR |
| LT 42 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY LVL XMTR |
| PC 169 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL PRESS CONT |
| PC 173 | P3-5 | INT P FLASH DRUM VAPOR OUTL PRESS CONT |
| PC 182 | P3-6 | FILTER FEED SURGE VSL HYDROCARBON VAPOR OUTL PRESS CONT |
| PC 2195 | P3-6 | FLASH COND SEPARATORS HYDROCARBON VAPOR OUTL PRESS CONT |
| PC 28 | P3-6 | FILTER FEED FLASH VSL HYDROCARBON VAPOR OUTL PRESS CONT |
| PC 35 | P3-7 | PRECOAT SLURRY PRESS VSL HYDROCARBON VAPOR OUTL PRESS CONT |
| PCD 2319 | P3-7 | PRECOAT SOLVENT CLR PRESS CONT DAMPER |
| PI 430S | P3-7 | PRECOAT FILTER A FILTRATE DSCH PRESS IND |
| PI 433S | P3-7 | PRECOAT FILTER B FILTRATE DSCH PRESS IND |
| PIC 2313 | P3-6 | RECYCLE PROCESS WTR TNK VENT PRESS IND CONT |
| PS 740 | P3-6 | FLASH COND SEPARATOR 2 HI-HI LVL SW |
| PS 742 | P3-10 | DRYER CONDENSATE DRUM PURGE PRESS SW |
| PS 758 | P3-10 | MINERAL RESIDUE COOLER CLG WTR SPLY PRESS SW |
| PS 779 | P3-4 | SLURRY PREHEATER PRESS SW<br>PART VENDOR FUEL CONT |
| PSV 316 | P3-7 | PRECOAT SLURRY DSCH PMP DSCH PRESS SFTY VLV |
| PSV 414 | P3-6 | FILTER FEED SURGE VSL HYDROCARBON VAPOR OUTL PRESS SFTY VLV |
| PSV 417 | P3-6 | FILTER FEED FLASH VSL HYDROCARBON VAPOR OUTL PRESS SFTY VLV |
| PSV 419 | P3-7 | PRECOAT SLURRY PRESS VSL HYDROCARBON VAPOR OUTL P SFTY VLV |
| PSV 420 | P3-7 | PRECOAT ATMOS MIX TNK DSCH PMP DSCH PRESS SFTY VLV |
| PSV 421 | P3-7 | PRECOAT ROTARY DRUM FLTR A HYDROCARBON VAPOR INLT P SFTY VLV |
| PSV 422 | P3-7 | PRECOAT ROTARY DRUM FLTR B HYDROCARBON VAPOR INLT P SFTY VLV |
| PSV 456 | P3-5 | INT P FLASH DRUM VAPOR OUTL PRESS SFTY VLV |
| PSV 465 | P3-7 | FILTER SOLVENT SPLY EXGR A DOWTHERM OUTL PRESS SFTY VLV |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PSV 466 | P3-7 | FILTER SOLVENT SPLY EXGR B DOWTHERM OUTL PRESS SFTY VLV |
| PSV 474 | P3-7 | PRECOAT SLURRY RCIRC EXGR DOWTHERM RETURN PRESS SFTY VLV |
| PSV 515 | P3-7 | PRECOAT SLURRY RCIRC PMP DSCH PRESS SFTY VLV |
| PSV 546 | P3-6 | WATER BOOSTER PUMP DISCH PRESS SFTY VLV |
| PSV 547 | P3-6 | FLASH COND SEPARATOR 1 PRESS SFTY VLV |
| PSV 548 | P3-6 | FLASH COND SEPARATOR 2 PRESS SFTY VLV |
| PSV 552 | P3-10 | DRYER CONDENSATE DRUM PRESS SFTY VLV |
| PT 88 | P3-4 | SLURRY PREHEATER INLET PT |
| PT 89 | P3-4 | SLURRY PREHEATER PT |
| PT 90 | P3-4 | SLURRY PREHEATER PT |
| PT 91 | P3-4 | SLURRY PREHEATER PT |
| PT 92 | P3-4 | SLURRY PREHEATER PT |
| PT 93 | P3-4 | SLURRY PREHEATER OUTLET PT |
| PT 169 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL PRESS XMTR |
| PT 173 | P3-5 | INT P FLASH DRUM VAPOR OUTL PRESS XMTR |
| PT 182 | P3-6 | FILTER FEED SURGE VSL HYDROCARBON VAPOR OUTL PRESS XMTR |
| PT 2114 | P3-4 | RECYCLE HYDROGEN SCRUBBER OUTL PT |
| PT 2195 | P3-6 | FLASH COND SEPARATORS HYDROCARBON VAPOR OUTL PRESS XMTR |
| PT 2216 | P3-10 | DRYER EXHAUST BLOWER DSCH PRESS XMTR |
| PT 28 | P3-6 | FILTER FEED FLASH VSL HYDROCARBON VAPOR OUTL PRESS XMTR |
| PT 298A | P3-6 | PRECOAT ROTARY DRUM FLTR A HYDROCARBON VAPOR INLT PRESS XMTR |
| PT 298B | P3-7 | PRECOAT ROTARY DRUM FLTR A COAL SOLN OUTL PRESS XMTR |
| PT 299A | P3-7 | PRECOAT ROTARY DRUM FLTR B HYDROCARBON VAPOR INLT PRESS XMTR |
| PT 299B | P3-7 | PRECOAT ROTARY DRUM FLTR B COAL SOLN OUTL PRESS XMTR |
| R 303 | P3-6 | WATER BOOSTER PMP DISCH TEMP REC |
| R 304 | P3-4 | SLURRY PREHEATER TEMPERATURE RECORDER |
| R 308 | P3-4 | SLURRY PREHEATER PRESSURE RECORDER |
| R 309 | P3-4 | SLURRY PREHEATER PRESSURE RECORDER (PURGE LINE |
| R 310 | P3-6 | WATER BOOSTER PMP DISCH FLOW REC |
| R 311 | P3-4 | SLURRY PREHEATER HYDROGEN/SYNTHESIS GAS INLET FLOW RCORDER |
| R 313 | P3-4 | SLURRY PREHEATER OUTLET TEMPERATURE RECORDER |
| R 314 | P3-5 | DISSOLVER A TEMP REC |
| R 315 | P3-5 | DISSOLVER B TEMP REC |
| R 317 | P3-6 | FILTER FEED FLASH VSL TEMP REC |
| R 319 | P3-5 | HP FLASH DRUM SLURRY TEMP REC |
| R 323 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL FLOW REC |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| R 324 | P3-5 | RECYCLE COND SEPARATOR HYDROCARBON VAPOR OUTL PRESS REC |
| R 325 | P3-5 | INT P FLASH DRUM VAPOR OUTL FLOW REC |
| R 332 | P3-7 | FILTER SOLVENT SPLY EXGR A/B OUTL TEMP REC |
| R 342 | P3-6 | FILTER FEED FLASH VSL LVL REC |
| R 343 | P3-6 | FILTER FEED FLASH VSL HYDROCARBON VAPOR OUTL PRESS REC |
| R 346A | P3-6 | FILTER FEED SURGE VSL TEMP REC |
| R 346B | P3-6 | FLASH COND SEPARATOR 1 TEMP REC |
| R 346C | P3-6 | FLASH COND SEPARATOR 2 TEMP REC |
| R 346D | P3-7 | PRECOAT ROTARY DRUM FLTR A/B TEMP REC |
| R 348 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY INLT/OUTL FLOW REC |
| R 349 | P3-7 | PRECOAT ROTARY DRUM FLTR B INLT/OUTL FLOW REC |
| R 350 | P3-7 | FILTER SOLVENT SPLY EXGR A/B INLT FLOW REC |
| R 375 | P3-5 | RECYCLE CONDENSATE SEPARATOR LIQ HYDROCARBONS OUTL FLOW REC |
| R 376 | P3-5 | RECYCLE CONDENSATE SEPARATOR TEMP REC |
| R 377 | P3-6 | FLASH COND SEPARATORS HYDROCARBON VAPOR OUTL FLOW REC |
| R 386 | P3-5 | INT P FLASH DRUM SLURRY OUTL VISCOSITY REC |
| R 388 | P3-7 | PRECOAT ROTARY DRUM FLTRS HYDROCARBON VAPOR INLT PRESS REC |
| R 391 | P3-7 | PRECOAT SLURRY PRESS VSL LVL REC |
| R 399 | P3-7 | PRECOAT SLURRY PRESS VSL TEMP REC |
| SI 2239 | P3-7 | PRECOAT ROTARY DRUM FLTR A SPEED IND |
| SI 2241 | P3-7 | PRECOAT ROTARY DRUM FLTR B SPEED IND |
| ST 2239 | P3-7 | PRECOAT ROTARY DRUM FLTR A SPEED XMTR |
| ST 2241 | P3-7 | PRECOAT ROTARY DRUM FLTR B SPEED XMTR |
| TC 105 | P3-4 | SLURRY PREHEATER OUTLET TC<br>TIES INTO VENDORS PKG |
| TC 167 | P3-5 | HP FLASH DRUM SLURRY TEMP CONT |
| TC 32 | P3-6 | FILTER FEED FLASH VSL TEMP CONT |
| TC 33 | P3-7 | PRECOAT SLURRY PRESS VSL TEMP CONT |
| TC 40 | P3-7 | FILTER SOLVENT SPLY EXGR A OUTL TEMP CONT |
| TC 45 | P3-7 | FILTER SOLVENT SPLY EXGR B OUTL TEMP CONT |
| TE 105 | P3-4 | SLURRY PREHEATER OUTLET TE |
| R 315 | P3-5 | DISSOLVER B TEMP REC |
| TE 138A | P3-5 | DISSOLVER A TEMP ELEM A-H |
| TE 167 | P3-5 | HP FLASH DRUM SLURRY TEMP ELEM |
| TE 171 | P3-5 | RECYCLE CONDENSATE SEPARATOR TEMP ELEM |
| TE 176 | P3-5 | INT P FLASH DRUM SLURRY TEMP ELEM |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TE 180 | P3-6 | FILTER FEED SURGE VSL TEMP ELEM |
| TE 2113 | P3-4 | RECYCLE HYDROGEN SCRUBBER OUTL TEMP ELEM |
| TE 2200 | P3-6 | FILTER FEED FLASH RCIRC EXGR LIQ HYDROCARBONS INLT TEMP ELEM |
| TE 2219 | P3-7 | FILTER SOLVENT SPLY EXGR B INLT TEMP ELEM |
| TE 2273 | P3-6 | FLASH COND SEPARATOR 1 TEMP ELEM |
| TE 2274 | P3-6 | FLASH COND SEPARATOR 2 TEMP ELEM |
| TE 2287 | P3-4 | SLURRY PREHEATER INLET TE |
| TE 2302 | P3-10 | MINERAL RESIDUE COOLER OUTL TEMP ELEM |
| TE 2310 | P3-10 | REGENERATOR BED TEMPERATURE ELEMENT |
| TE 2311 | P3-6 | WATER BOOSTER PMP DISCH TEMP ELEM |
| TE 2312 | P3-4 | SLURRY PREHEATER STACK TE |
| TE 32 | P3-6 | FILTER FEED FLASH VSL TEMP ELEM |
| TE 33 | P3-7 | PRECOAT SLURRY PRESS VSL TEMP ELEM |
| TE 40 | P3-7 | FILTER SOLVENT SPLY EXGR A OUTL TEMP ELEM |
| TE 45 | P3-7 | FIL TER SOLVENT SPLY EXGR B OUTL TEMP ELEM |
| TE 46 | P3-7 | PRECOAT ROTARY DRUM FLTR A TEMP ELEM |
| TE 48 | P3-7 | PRECOAT ROTARY DRUM FLTR B TEMP ELEM |
| TE 709 | P3-5 | HP FLASH DRUM VAPOR TEMP ELEM |
| TE 94 | P3-4 | SLURRY PREHEATER STACK TE |
| TE 95 | P3-4 | SLURRY PREHEATER INLET TE |
| TE 96 | P3-4 | SLURRY PREHEATER TE |
| TE 97 | P3-4 | SLURRY PREHEATER TE |
| TIC 2310 | P3-10 | DRYER CONDENSATE COOLER OUTL TEMP IND CONT |
| VE 2233 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY INLT VISCOSITY ELEM |
| VE 2234 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY INLT VISCOSITY ELEM |
| VT 2231 | P3-5 | INT P FLASH DRUM SLURRY OUTL VISCOSITY XMTR |
| VT 2233 | P3-7 | PRECOAT ROTARY DRUM FLTR A SLURRY INLT VISCOSITY XMTR |
| VT 2234 | P3-7 | PRECOAT ROTARY DRUM FLTR B SLURRY INLT VISCOSITY XMTR |
| WX 1001 | P3-10 | MISC WEIGH SYSTEMS ILLEGIBLE REPRO- NO ENTRY |
| XA 1003 | P3-7 | 3 UNLISTED ANNUNCIATORS |
| XA 1008 | P3-10 | 8 MISC ANNUNCIATORS UNLISTED |
| XF 1002 | P3-4 | 2 MISC FLOW DEVICES UNLISTED |
| XF 1007 | P3-5 | 7 UNLISTED FLOW DEVICES |
| XF 1008 | P3-6 | 8 UNLISTED FLOW DEVICES |
| XL 1005 | P3-10 | 5 UNLISTED LEVEL DEVICES |
| XP 1010 | P3-6 | 10 UNLISTED PRESS DEVICES |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| XP 1012 | P3-10 | 12 MISC UNLISTED PRESSURE DEVICES |
| XP 1015 | P3-4 | 15 UNLISTED COMMON PRESS DEVICES |
| XP 1015A | P3-7 | 15 MISC PRESS DEVICES UNLISTED |
| XT 1002 | P3-4 | 2 MISC TEMP DEVICES UNLISTED |
| XT 1004 | P3-10 | 4 UNLISTED TEMP IND |
| XT 1007 | P3-6 | 12 UNLISTED TEMP DEVICES |
| XT 1009 | P3-7 | 9 UNLISTED TEMP DEVICES |
| XV 1025 | P3-10 | 25 MISC VENDOR FURNISHED DEVICES ON ROTARY KILN |
| XX 001 | P3-3 | AREA 01 COAL RECEIVING & PREPARATION, DEVICES UNLISTED APPROX 50 DEVICES UNLISTED--PRESS LVL SWS ETC DRAWING POOR REPRO EST APPROX 40% VENDOR PKGS |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SYNTHANE PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET LCO | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AAH 208 | 02005E-5 | ACID GAS ABSORBER HIGH CO2 ALARM |
| AR 208 | 02005E-5 | ACID GAS ABSORBER RAW GAS ANALYSIS RECORDER |
| AR 241 | 02005E-5 | ACID GAS ABSORBER RAW GAS ANALYSIS RECORDER |
| FAL 212 | 02005E-5 | MAJOR H.P.C. CIRC LOW FLOW ALARM |
| FCV 209 | 02005D-4 | ABSORBER FEED INLET FLOW CONTROL VALVE |
| FDIC 209 | 02005D-4 | ABSORBER FEED DIFFL FLOW INDICATING CONTROLLER |
| FI 242 | 02005E-5 | ACID GAS ABSORBER RAW GAS FLOW INDICATOR |
| FIC 212 | 02005E-5 | MAJOR H.P.C. CIRC FLOW IND CONT |
| FR 209 | 02005D-4 | ABSORBER FEED INLET FLOW RECORDER |
| FRC 210 | 02005D-4 | ABSORBER FEED INLET FLOW RECORDER CONTROLLER |
| LAHL 206 | 02005E-5 | ACID GAS ABSORBER HIGH LEVEL ALARM |
| LIC 206 | 02005E-5 | ACID GAS ASORBER LEVEL INDICATING CONTROLLER |
| LLL 402 | 04005A-4 | CHAR LOCK HOPPER LOW LEVEL LIGHT |
| PAH 267 | 02005A-4 | PRETREATER HIGH PRESSURE ALARM |
| PAN 206 | 02005E-5 | ACID GAS ABSORBER RAW GAS PRESS ALARM |
| PB 228 | 02005A-4 | GASIFIER CHAR COOLER EFFLUENT STEAM CONTROL PUSHBUTTON RESET |
| PC 242 | 02005E-5 | THERMAL OXIDIZER STACK INLET PRESS CONTROLLER |
| PDI 222 | 02005D-4 | STEAM FILTER DIFFL PRESS IND |
| PDI 223 | 02005D-4 | STEAM FILTER DIFFL PRESS INDICATOR |
| PDI 232 | 02005E-5 | H.P.C FILTER DIFFL PRESS IND |
| PDI 255 | 02005A-4 | PRETEATER DIFFL PRESS IND |
| PI 224 | 02005D-4 | STEAM FILTER PRESS INDICATOR |
| PI 225 | 02005D-4 | STEAM FILTER PRESS INDICATOR |
| PI 227 | 02005D-4 | ABSORBER FEED INLET PRESS IND |
| PI 229 | 02005D-4 | SHIFT CONVERTER DSCH PRESS INDICATOR |
| PI 267 | 02005A-4 | ALTERNATE PRETREATER PRESS IND |
| PIC 206 | 02005E-5 | ACID GAS ABSORBER RAW GAS PRESS IND CONT |
| PS 401 | 00462A-1 | CHAR LOCK HOPPER PRESS SWITCH<br>CHECK PROCESS |
| SC 205 | 02005E-5 | ACID GAS ABSORBER SAMPLE COOLER |
| SC 208 | 02005E-5 | ABSORBENT REGNTR CORBONATE LIQUID SAMPLE COOLER |
| SC 209 | 02005E-5 | ABSORBENT REGENERATOR SAMPLE COOLER |
| SW 209 | 02005D-4 | ABSORBER FEED INLET SELECTOR SWITCH |
| SW 254 | 02005A-4 | PRETREATER SELECTOR SWITCH |
| SW 255 | 02005A-4 | PRETREATER SELECTOR SWITCH |
| SW 267 | 02005A-4 | PRETREATER SELECTOR SWITCH |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SYNTHANE PROCESS
INSTRUMENTS WHICH ARE ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET LCO | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TAH 215 | 02005D-4 | SHIFT CONVERTER HIGH TEMPERATURE ALARM |
| TE 203 A | 02005A-4 | PRETREATER TEMPERATURE ELEMENT |
| TI 200 | 02005A-4 | PRETREATER TEMPERATURE INDICATOR |
| TI 200A | 02005D-4 | SHIFT CONVERTER ATMOSPHERIC VENT TEMPERATURE INDICATOR |
| TI 200D4 | 02005D-4 | SHIFT CONVERTER TEMPERATURE INDICATOR |
| TR 255 | 02005A-4 | PRETREATER TEMPERATURE RECORDER |
| VPL 404B | 04005A-4 | CHAR LOCK HOPPER FILTER VALVE POSITIONER LIGHT |
| XF 103U | 02005A-4 | 6 UNLISTED FLOW DEVICES |
| XF 106U | 02005D-4 | 2 UNLISTED FLOW DEVICES |
| XL 103U | 02005A-4 | 3 UNLISTED LEVEL DEVICES |
| XL 106U | 02005D-4 | 3 UNLISTED LEVEL DEVICES |
| XP 103U | 02005A-4 | 14 UNLISTED PRESSURE DEVICES |
| XP 106U | 02005D-4 | 8 UNLISTED PRESSURE DEVICES |
| XS 103U | | 4 UNLISTED SWITCHES |
| XT 103U | 02005A-4 | 14 UNLISTED TEMPERATURE DEVICES |
| XT 106U | 02005D-4 | 8 UNLISTED TEMP DEVICES |
| XX 107U | 02005B-5 | 48 MISC UNLISTED DEVICES |
| XX 112U | 04005A-4 | 73 MISC UNLISTED DEVICES<br>MOST OF THESE DEVICES WILL SCALE UP |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AN 203 | 111-4 | FIRST STAGE PYROLYZER FLUIDIZING GAS HI TEMP ANNUNCIATOR<br>07/18 NEED IMPROVED O2 ANZR |
| AR 001 | 111-4 | FIRST STAGE PYROLIZER FLUIDIZING GAS OXYGEN ANALYZER RCDR<br>CHECK PROCESS APPLICATION |
| AR 002T | 112-3 | RECYCLE GAS ANALYTICAL TRANSMITTER |
| FT 001 | 111-5 | PYROLYSIS GAS TO INCINERATOR FLOW TRANSMITTER<br>CHKD 08/18 INSTRUMENTS OK. SCALE UP SHOULD NAIL MASS FLOW |
| FT 021 | 112-3 | MAKE-UP HYDROGEN COMPRESSOR DISCHARGE FLOW TRANSMITTER<br>PROC APPLICATION |
| FT 208 | 111-5 | SCRUB LIQUOR TO VENTURI SCRUBBER COOLER FLOW TRANSMITTER<br>SEE FT 001 |
| FT 214 | 111-5 | SCRUB LIQUOR TO GAS LIQUID SEPARATOR FLOW TRANSMITTER<br>CHK PRDC COND |
| FT 225 | 111-6 | 30 KW RECYCLE GAS HEATER INLET FLOW TRANSMITTER<br>INSTRUMENTS OK HEATING ELEMENT NG |
| FT 235 | 111-6 | 30 KW RECYCLE GAS HEATER INLET FLOW TRANSMITTER<br>INST OK HEATER NG |
| FT 236 | 111-6 | 30 KW RECYCLE GAS HEATER INLET FLOW TRANSMITTER<br>INST OK HEATER NG. |
| FT 245 | 111-7 | 10 KW RECYCLE GAS HEATER INLET FLOW TRANSMITTER |
| FT 248 | 111-7 | 30 KW RECYCLE GAS HEATER INLET FLOW TRANSMITTER |
| FT 310 | 111-8 | VENTURI SCRUBBER SCRUB LIQUOR INLET FLOW TRANSMITTER<br>CHK PROC COND |
| FT 311 | 111-8 | GAS/LIQUID SEPARATOR SCRUB LIQUOR INLET FLOW TRANSMITTER<br>CHK PROC COND |
| FT 315 | 111-8 | VENTURI DEMISTER SCRUB LIQUOR INLET FLOW TRANSMITTER<br>CHK PROC COND |
| FT 419 | 112-3 | RECYCLE GAS FLOW TRANSMITTER<br>PROC APPLICATION |
| FT 437 | 112-3 | PURGE & VENT GAS FLOW TRANSMITTER<br>PROC APPLICATION |
| FTT 002 | 111-8 | SECOND STAGE GAS COMPRESSOR SUCTION TOTALIZING FLOW XMTR<br>CHK PROC COND |
| LC 217 | 111-5 | OIL/WATER DECANTER LEVEL CONTROL TRANSMITTER<br>EXISTING SYS WORKS. SCALE-UP DOUBTFUL. |
| LC 330 | 111-9 | OIL/WATER DECANTER HEAVY OIL LEVEL CONTROLLER<br>CHK INTERFACE |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| LC 331 | 111-9 | OIL/WATER DECANTER LIGHT OIL LEVEL CONTROLLER<br>CHK INTERFACE |
| LC 380 | 111-10 | ROTARY PRESSURE PRECOAT CRUDE OIL FILTER LEVEL CONTROLLER<br>CHK PROC |
| LG 001 | 111-5 | OIL/WATER DECANTER LIGHT OIL LEVEL GLASS<br>SEE LC 217 |
| LG 002 | 111-5 | OIL/WATER DECANTER HEAVY OIL LEVEL GLASS<br>SEE LC 217 |
| LG 003 | 111-9 | OIL/WATER DECANTER LIGHT OIL LEVEL GLASS<br>CHK INTERFACE |
| LG 004 | 111-9 | OIL/WATER DECANTER HEAVY OIL LEVEL GLASS<br>CHK INTERFACE |
| LIC 217 | 111-5 | OIL/LEVEL DECANTER INDICATING LEVEL CONTROLLER<br>SEE LC 217 |
| LT 210 | 111-4 | FIRST STAGE PYROLIZER FLUID BED HI LEVEL TRANSMITTER<br>CHECK PROC COND |
| LT 220 | 111-6 | SECOND STAGE PYROLYZER FLUID BED MID LVL LEVEL TRANSMITTER<br>INST OK SCALE UP SHOULD BE IMPROVED |
| LT 230 | 111-6 | THIRD STAGE PYROLYZER FLUID BED HI LVL LEVEL TRANSMITTER<br>INST OK IMPROVE FOR SCALE UP |
| LT 240 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED LEVEL TRANSMITTER<br>IMPROVE FOR SCALE-UP |
| LT 340 | 111-9 | HEAVY OIL DEHYDRATOR LEVEL TRANSMITTER<br>CHK INTERFACE |
| LT 350 | 111-9 | OIL DEHYDRATOR LEVEL TRANSMITTER<br>CHK INTERFACE |
| LT 360 | 111-9 | OIL STORAGE TANK A LEVEL TRANSMITTER<br>RELATE TO GENERAL UPDATE REVIEW |
| LT 361 | 111-9 | OIL STORAGE TANK B LEVEL TRANSMITTER<br>SEE LT 360 |
| PDT 152 | 111-4 | FIRST STAGE PYROLYZER COAL FLOW D/P TRANSMITTER<br>CHECK PROC. COND |
| PDT 202 | 111-6 | SECOND STAGE PYROLYZER FINES FLOW D/P TRANSMITTER<br>INSTRUMENTS WORK WELL. IMPROVE FOR SCALE-UP |
| PDT 208 | 111-5 | RECYCLE GAS PRESSURE DIFFERENTIAL TRANSMITTER<br>INSTRUMENT OK. SCALE-UP DOUBTFUL |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PDT 209 | 111-5 | PYROLYSIS GAS DIFFERENTIAL PRESSURE TRANSMITTER<br>INSTRUMENT OK SCALE UP DOUBTFUL |
| PDT 211 | 111-4 | FIRST STAGE PYROLYZER FLUID BED MID LVL D/P XMTR<br>CHECK PROC COND |
| PDT 212 | 111-4 | FIRST STAGE PYROLYZER CYCLONE A PURGE D/P XMTR<br>CHECK PROC. COND |
| PDT 213 | 111-4 | FIRST STAGE PYROLYZER PURGE LINE DIFFERENTIAL PRESS XMTR<br>CHECK PROC. COND |
| PDT 214 | 111-4 | FIRST STAGE PYROLYZER FLUID BED LO LVL D/P XMTR<br>CHECK PROC COND |
| PDT 215 | 111-4 | FIRST STAGE PYROLYZER CYCLONE B LVL D/P TRANSMITTER<br>CHECK PROC COND |
| PDT 216 | 111-5 | RECYCLE GAS DIFFERENTIAL PRESSURE TRANSMITTER<br>INSTRUMENT OK SCALE-UP DOUBTFUL |
| PDT 221 | 111-6 | SECOND STAGE PYROLYZER FLUID BED LO LVL D/P TRANSMITTER<br>INST. OK IMPROVE FOR SCALE-UP |
| PDT 223 | 111-6 | EXTERNAL CYCLONE PYROLYSIS GAS INLT FLOW D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 227 | 111-6 | SECOND STAGE PYROLIZER COAL FLOW D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 231 | 111-6 | THIRD STAGE PYROLYZER FLUID BED MID LVL D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 232 | 111-6 | THIRD STAGE PYROLYZER TOP/DSCH D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 233 | 111-6 | SECOND STAGE PYROLYZER FLUID BED GRATE LVL D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 235 | 111-6 | SECOND STAGE PYROLYZER MIXED COAL FLOW D/P TRANSMISTTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 236 | 111-7 | FOURTH STAGE PYROLYZER PYROLYSIS GAS DSCH D/P TRANSMITTER<br>IMPROVE FOR SCALE-UP |
| PDT 237 | 111-6 | THIRD STAGE PYROLYZER CHAR INLT FLOW D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 241 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED MID LEVEL D/P TRANSMITTER<br>IMPROVE FOR SCALE-UP |
| PDT 242 | 111-7 | FOURTH STAGE PYROLYZER HI LVL DIFFERENTIAL PRESSURE XMTR<br>IMPROVE FOR SCALE-UP |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PDT 243 | 111-6 | THIRD STAGE PYROLYZER FLUID BED LO LVL D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 245 | 111-6 | THIRD STAGE PYROLYZER COAL/CHAR INLT FLOW D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 249 | 111-7 | FOURTH STAGE PYROLYZER FLUID BED LO LVL D/P TRANSMITER<br>IMPROVE FOR SCALE-UP |
| PDT 272 | 111-6 | SECOND STAGE PYROLYZER CYCLONE B LVL D/P TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PDT 318 | 111-8 | PYROLYSIS GAS DIFFERENTIAL PRESSURE TRANSMITTER<br>CHK PROC COND |
| PDT 319 | 111-8 | GAS/WATER SEPARATOR PYROLYSIS GAS LINE D/P TRANSMITTER<br>CHK PROC COND |
| PI 001 | 111-3 | VELOCITY SEPARATOR DISCHARGE PRESSURE<br>CHECK PROC COND |
| PI 037 | 111-6 | EXTERNAL CYCLONE PYROLYSIS GAS INLT PRESS IND<br>INST OK IMPROVE FOR SCALE-UP |
| PT 210 | 111-4 | FIRST STAGE PYROLYZER CYCLONE B PRESS TRANSMITTER<br>IMPROVE FOR SALE UP |
| PT 220 | 111-6 | SECOND STAGE PYROLYZER CYCLONE B LVL PRESSURE TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| PT 230 | 111-6 | THIRD STAGE PYROLYZER CYCLONE B LVL PRESSURE TRANSMITTER<br>INST OK IMPROVE FOR SCALE-UP |
| S 205 | 111-4 | 10 KW RECYCLE GAS HEATER TRIP<br>RECOMMEND BETTER HTR |
| S 219 | 111-4 | 1.5 KW RECYCLE GAS HEATER TRIP<br>RECOMMEND BETTER HTR |
| S 225 | 111-6 | 30 KW RECYCLE GAS HEATER HIGH SHEATH TEMP TRIP<br>INST OK RECOMMEND BETTER HEATER FOR SCALE-UP |
| S 235 | 111-6 | 30 KW RECYCLE GAS HEATER HI SHEATH TEMP SWITCH<br>INST OK RECOMMEND BETTER HEATER FOR SCALE-UP |
| S 236 | 111-6 | 30 KW RECYCLE GAS HEATER SHEATH TEMPERATURE HI SWITCH<br>INST. OK REVIEW FOR BETTER HTR |
| S 245 | 111-7 | 10 KW RECYCLE GAS HEATER ALARM<br>RECOMMEND BETTER HTR |
| S 246 | 111-7 | 25 KW OXYGEN HEATER HI SHEATH TEMPERATURE ALARM<br>RECOMMEND BETTER HTR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| S 247 | 111-7 | 35 KW STEAM SUPERHEATER HI SHEATH TEMP ALARM<br>RECOMMEND BETTER HEATER |
| S 248 | 111-7 | 30 KW RECYCLE GAS HEATER HI SHEATH TEMP ALARM<br>RECOMMEND BETTER HTR |
| TC 205 | 111-4 | 10 KW RECYCLE GAS HEATER TEMPERATURE CONTROLLER<br>RECOMMEND BETTER HTR |
| TC 219 | 111-4 | 1.5 KW RECYCLE GAS HEATER TEMPERATURE CONTROLLER<br>RECOMMEND BETTER HTR |
| TC 225 | 111-6 | 30 KW RECYCLE GAS HEATER SHEATH TEMP CONTROL<br>INST OK. RECOMMEND BETTER HTR |
| TC 235 | 111-6 | 30 KW RECYCLE GAS HEATER SHEATH TEMP CONTROL<br>INST OK RECOMMEND BETTER HTR |
| TC 236 | 111-6 | 30 KW RECYCLE GAS HEATER SHEATH TEMPERATURE<br>INST OK RECOMMEND BETTER HTR |
| TC 245 | 111-7 | 10 KW RECYCLE GAS HEATER TEMPERATURE CONTROL<br>RECOMMEND BETTER HTR |
| TC 246 | 111-7 | 25 KW OXYGEN HEATER SHEATH TEMP CONTROL<br>RECOMMEND BETTER HTR |
| TC 247 | 111-7 | 35 KW STEAM SUPERHEATER HI SHEATH TEMP CONTROL<br>RECOMMEND BETTER HTR |
| TC 248 | 111-7 | 30 KW RECYCLE GAS HEATER HI SHEATH TEMP CONT<br>RECOMMEND BETTER HTR |
| TI 041 | 111-9 | OIL/WATER DECANTER HEAVY OIL TEMPERATURE INDICATOR |
| TIC 205 | 111-4 | 10 KW RECYCLE GAS HEATER OUTLET TEMPERATURE CONTROLLER<br>RECOMMEND BETTER HEATER |
| TIC 205C | 111-4 | 10 KW RECYCLE GAS HEATER INLET TEMPERATURE CONTROLLER<br>RECOMMEND BETTER HTR |
| TIC 219 | 111-4 | 1.5 KW RECYCLE GAS HEATER OUTLET TEMPERATURE CONTROLLER<br>RECOMMEND BETTER HTR |
| TIC 219C | 111-4 | 1.5 KW RECYCLE GAS HEATER INLET TEMPERATURE CONTROLLER<br>RECOMMEND BETTER HTR |
| TIC 225 | 111-6 | 30 KW RECYCLE GAS HEATER OUTLET TEMPERATURE INDICATING CONT<br>RECOMMEND BETTER HTR |
| TIC 225C | 111-6 | 30 KW RECYCLE GAS HEATER INDICATING TEMP CONTROL<br>RECOMMEND BETTER HTR |
| TIC 235 | 111-6 | 30 KW RECYCLE GAS HEATER OUTLET INDICATING TEMP CONTROL<br>RECOMMEND BETTER HTR |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| TIC 235C | 111-6 | 30 KW RECYCLE GAS HEATER INDICATING TEMP CONTROL<br>RECOMMEND BETTER HTR |
| TIC 236 | 111-6 | 30 KW RECYCLE GAS HEATER OUTLET INDICATING TEMP CONTROL<br>RECOMMEND BETTER HEATER |
| TIC 236C | 111-6 | 30 KW RECYCLE GAS HEATER INDICATING SHEATH TEMP CONTROL<br>RECOMMEND BETTER HTR |
| TIC 247C | 111-7 | 35 KW STEAM SUPERHEATER SHEATH TEMP INDICATING CONTROL<br>RECOMMEND BETTER HTR |
| TIC 248 | 111-7 | 30 KW RECYCLE GAS HEATER OUTLET TEMPERATURE IND CONTROL<br>RECOMMEND BETTER HTR |
| TIC 248C | 111-7 | 30 KW RECYCLE GAS HEATER HI SHEATH TEMP IND CONTROL<br>RECOMMEND BETTER HTR |
| TIC 350 | 111-9 | OIL DEHYDRATOR TEMPERATURE INDICATING CONTROLLER<br>CHK PROC |
| TIC 360 | 111-9 | OIL STORAGE TANK A TEMPERATURE INDICATING CONTROLLER<br>CHK PROC |
| TIC 361 | 111-9 | OIL SOTRAGE TANK B TEMPERATURE INDICATING CONTROLLER<br>CHK PROC |
| TT 220 | 111-6 | SECOND STAGE PYROLYZER FLUID BED HI LVL TEMP TRANSMITTER<br>IMPROVE FOR SCALE-UP |
| TT 225 | 111-6 | 30 KW RECYCLE GAS HEATER OUTLET TEMPERATURE TRANSMITTER<br>RECOMMEND BETTER HEATER |
| TT 230 | 111-6 | THIRD STAGE PYROLYZER FLUID BED TEMPERATURE TRANSMITTER<br>IMPROVE INSTRUMENTATION FOR SCALE-UP |
| TT 235 | 111-6 | 30 KW RECYCLE GAS HEATER OUTLET TEMPERATURE TRANSMITTER<br>RECOMMEND BETTER HEATER |
| TT 236 | 111-6 | 30 KW RECYCLE GAS HEATER OUTLET TEMPERATURE TRANSMITTER<br>RECOMMEND BETTER HEATER |
| WS 001 | 111-3 | PULVERIZED COAL WEIGH HOPPER W-48154<br>FLOW MEASUREMENT FOR COMMERCIAL PLANTS |
| WS 002 | 111-5 | FIRST STAGE OIL WEIGH SCALE<br>CONTINUOUS FLOW MSMT FOR COMMERCIAL PLANTS |
| WS 003 | 111-6 | FINES WEIGH SCALE W-48303<br>CHECK VOLUME FOR FULL SCALE OPERATION |
| WS 005 | 111-9 | PRODUCT OIL WEIGH SCALE W-48363<br>REQUEST VOL/TON FROM COED PILOT PLANT |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE COED PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET BKC 2383 | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| WS 006 | 111-10 | FILTER FEED TANK WEIGH SCALE W-48393<br>REQUEST DATA FROM SITE LBS/TON COAL FEED |
| WS 007 | 112-1 | OIL FEED TANK WEIGH SCALE W-48409A<br>REQUEST LB/HR/TON COAL FEED |
| WS 008 | 112-1 | OIL FEED TANK WEIGH SCALE W-48409B<br>REQUEST LB/HR/TON COAL FEED |
| WS 009 | 112-2 | LIGHT OIL TANK WEIGH SCALE W-48432<br>ESTIMATE FOR 250 T/D PLANT 3 TO 5 GPH |
| WS 010 | 112-3 | HEAVY OIL PRODUCT TANK WEIGH SCALE W-48447A<br>ESTIMATE 250T/D PLANT 7 TO 10 GPM TOTAL FLOW |
| WS 011 | 112-3 | HEAVY OIL PRODUCT TANK WEIGH SCALE W-48447B<br>SEE WS 010 |
| WS 012 | | WASTE WATER TANK WEIGH SCALE W-48470<br>REQUEST DATA FROM SITE LBS/TON COAL FEED |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AI 3002 | 208 | SO2 SCRUBBER WST WTR OUTL PH ANALYSIS IND |
| | | SEE AT 3002 |
| AIT 2001 | 205 | RG CYCLONE FLUE GAS OUTL O2 ANALYSIS IND XMTR |
| AIT 2002 | 205 | RG CYCLONE FLUE GAS OUTL CO ANALYSIS IND XMTR |
| AIT 3000 | 208 | RG QUENCHER QUENCHED FLUE GAS OUTL CO2 ANALYSIS IND XMTR |
| | | CHECK MFR, SERVICE, TROUBLE |
| AIT 3001 | 208 | ABSORBER CONDENSER OUTL SAMPLE ANALYSIS IND XMTR |
| | | CHK MFR,SERVICE,AND TROUBLE ALSO CHECK APPLICATION |
| AM 3000 | 208 | RG QUENCHER QUENCHED FLUE GAS OUTL CO2 ANALYSIS XDCR |
| | | SEE AIT 3000 |
| AM 3001 | 208 | ABSORBER CONDENSER OUTL SAMPLE ANALYSIS XDCR |
| | | SEE AIT 3001 |
| AR 3000 | 208 | RG QUENCHER QUENCHED FLUE GAS OUTL CO2 ANALYSIS REC |
| | | SEE AIT 3000 |
| AR 3001 | 208 | ABSORBER CONDENSER OUTL SAMPLE ANALYSIS RECORDER |
| | | SEE AIT 3001 |
| ASL 3002 | 208 | SO2 SCRUBBER WST WTR OUTL LO PH SW |
| | | SEE AT 3002 |
| AT 3002 | 208 | SO2 SCRUBBER WST WTR OUTL PH ANALYSIS XMTR |
| | | SEE IF PARTICULAR DEVICE IS APPLICABLE TO FLUID |
| DPIT 2079 | 203-1 | PURGE GAS B D/P INDICATING |
| | | INSTRUMENT LINE-UP IS QUESTIONABLE,ESPECIALLY ON H2 |
| DPSL 2045 | 203-1 | DEVOLATILIZER DIFFERENTIAL PRESSURE SWITCH LOW |
| | | CHECK APPLICATION |
| DPSL 2046 | 203-1 | DEVOLATILIZER/CYCLONE DSCH PRESS/RECYCLE GAS D/P SWITCH HIGH |
| DPSL 2047 | 203-1 | DEVOLATILIZER/FLUE GAS D/P SWITCH LOW |
| DPSL 2048 | 203-1 | GASIFIER DOLOMITE LEVEL D/P SWITCH |
| DPSL 2049 | 203-1 | RECYCLE GAS/SPENT CHAR LINE D/P SWITCH LOW |
| DPT 1001 | 202 | LIGNITE PRHTR BED LVL D/P XMTR |
| DPT 1002 | 202 | LIGNITE PRHTR BED LVL D/P XMTR |
| DPT 1003 | 202 | LIGNITE PRHTER BED LVL D/P XMTR |
| DPT 2000 | 203-1 | DEVOLATILIZER TOP/FLUE GAS D/P TRANSMITTER |
| DPT 2001 | 203-1 | GASIFIER SPENT DOLOMITE POT LEVEL D/P TRANSMITTER HIGH |
| DPT 2001HL | 203-1 | DEVOLATILIZER FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2002 | 203-1 | DEVOLATILIZER FLUID BED LEVEL |
| DPT 2002HL | 203-1 | GASIFIER SPENT DOLOMITE LEVEL D/P TRANSMITTER HI/LO |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| DPT 2003 | 203-1 | DEVOLATILIZER FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2003HL | 203-1 | GASIFIER DOLOMITE POT LEVEL HIGH D/P TRANSMITTER |
| DPT 2004 | 203-1 | DEVOLATILIZER SPENT DOLOMITE POT LEVEL D/P TRANSMITTER |
| DPT 2005 | 203-1 | DEVOLATILIZER SPENT DOLOMITE POT LEVEL D/P TRANSMITTER |
| DPT 2005HL | 203-1 | GASIFIER FLUIDIZED BED LEVEL D/P TRANSMITTER |
| DPT 2006 | 203-1 | DOLOMITE DUMP HOPPER LEVEL D/P TRANSMITTER |
| DPT 2007 | 203-1 | SPENT DOLOMITE LINE D/P TRANSMITTER |
| DPT 2008 | 203-1 | DOLOMITE LINE D/P TRANSMITTER |
| DPT 2009 | 203-1 | DOLOMITE LINE D/P TRANSMITTER |
| DPT 2010 | 203-1 | DOLOMITE LINE D/P PRESSURE |
| DPT 2013 | 203-1 | COKE/CHAR LIFT LINE D/P TRANSMITTER |
| DPT 2014 | 203-1 | GASIFIER CHAR DISCHARGE LINE DIFFERENTIAL PRESS XMTR |
| DPT 2021 | 203-1 | SPENT DOLOMITE/LIFT GAS D/P TRANSMITTER |
| DPT 2022 | 203-1 | SPENT DOLOMITE LINE D/P TRANSMITTER |
| DPT 2025 | 203-1 | DOLOMITE SUPPLY LINE D/P TRANSMITTER |
| DPT 2026 | 203-1 | DOLOMITE SUPPLY LINE D/P TRANSMITTER |
| DPT 2027 | 203-1 | SPENT CHAR LINE DIFFERENTIAL PRESSURE TRANSMITTER |
| DPT 2028 | 203-1 | SPENT CHAR LINE DIFFERENTIAL PRESSURE TRANSMITTER |
| DPT 2029 | 203-1 | SPENT CHAR DSCH LINE PRESSURE TRANSMITTER |
| DPT 2030 | 203-1 | PROCESS GAS 1/2 DIFFERENTIAL PRESSURE TRANSMITTER |
| DPT 2031 | 203-1 | GASIFIER FLUID BED LEVEL DIFFERENTIAL PRESSURE TRANSMITTER |
| DPT 2032 | 203-1 | GASIFIER FLUID BED LEVEL DIFFERENTIAL PRESSURE XMTR |
| DPT 2033 | 203-1 | GASIFIER FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2034 | 203-1 | GASIFIER SPENT DOLOMITE BED LEVEL D/P TRANSMITTER HI/LO |
| DPT 2035 | 203-1 | GASIFIER SPENT DOLOMITE BED LEVEL D/P TRANSMITTER HI/LO |
| DPT 2036 | 203-1 | COKE LINE DIFFERENTIAL PRESSURE TRANSMITTER |
| DPT 2037 | 203-1 | SPENT DOLOMITE LINE DIFFERENTIAL PRESSURE TRANSMITTER |
| DPT 2043 | 203-1 | DEVOLATILIZER D/P TRANSMITTER |
| DPT 2044 | 203-1 | PROCESS GAS 1/2 DIFFERENTIAL PRESSURE TRANSMITTER |
| DPT 2070 | 203-1 | GASIFIER FLUIDIZED BED LEVEL D/P TRANSMITTER |
| DPT 2073 | 203-1 | REGENERATOR FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2074 | 203-1 | REGENERATOR FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2075 | 203-1 | REGENERATOR FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2076 | 203-1 | REGENERATOR FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2077 | 203-1 | REGENERATOR FLUID BED LEVEL D/P TRANSMITTER |
| DPT 2078 | 203-1 | GASIFIER SPENT DOLOMITE BED LEVEL D/P TRANSMITTER HI/LO |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| FI 1010 | 203-2 | LIGNITE PREHEATER BED LEVEL D/P LINE PURGE FLOW IND<br>ASSOC INSTRUMENTS ON B201,202 & 203-1 FREQUENTLY SHOW LOCATIONS DIFFERENT FROM 203-1,INDICATING A CLOSER SCRUTINY OF PURGE FLOW INDICATORS IN PLANTS |
| FI 2087 | 203-1 | REGENERATOR DOLOMITE DSCH FLOW INDICATOR<br>SEE TE 2317 |
| FI 2139 | 203-1 | PURGE GAS B-H2-FLOW INDICATOR<br>SEE DPIT 2079 |
| FR 2134 | 203-1 | PURGE GAS B FLOW RECORDER |
| FT 2134 | 203-1 | PURGE GAS B FLOW TRANSMITTER |
| LC 3010 | 206 | GF QUENCH SEPARATOR WASTE OIL LVL CONT |
| LC 3012 | 206 | GF QUENCH SEPARATOR LVL CONTROLLER |
| LC 3027 | 207 | DV QUENCH SEPARATOR LVL CONT |
| LC 3035 | 207 | DV QUENCH SEPARATOR LVL CONT |
| LC 3078 | 206 | GF VENTURI LEVEL CONTROLLER |
| LCV 2000A | 203-2 | PYROLIZER FLOW CONTROL VALVE<br>PART OF PURGE SYSTEM BUT NOT TIED TO OTHER DEVICES |
| LCV 2000A | 203-2 | PYROLIZER FLOW CONTROL VALVE<br>HOLD AND REVIEW IN RETRIEVAL |
| LSH 1000 | 201 | DOLOMITE SILO A LEVEL SWITCH |
| LSH 1002 | 201 | DOLOMITE SILO B LEVEL SWITCH HIGH |
| LSH 1004 | 201 | DOLOMITE BIN LEVEL SWITCH HIGH |
| LSH 1006 | 201 | DOLOMITE FINES BIN LEVEL SWITCH HIGH |
| LSH 1011 | 201 | LIGNITE SURGE BIN LEVEL SWITCH HIGH<br>MOTOR INTERLOCK |
| LSH 1014 | 201 | LIGNITE CYCLONE LEVEL SWITCH HIGH |
| LSH 1020 | 201 | LIGNITE FINES BIN LEVEL SWITCH HIGH |
| LSH 3086A | 207 | DV VENTURI HI LVL SW<br>MIGHT BE PROBLEM WITH FINES |
| LSL 1001 | 201 | DOLOMITE SILO A LEVEL SWITCH LOW |
| LSL 1003 | 201 | DOLOMITE SILO B LEVEL SWITCH LOW |
| LSL 1005 | 201 | DOLOMITE BIN LEVEL SWITCH LOW |
| LSL 1012 | 201 | LIGNITE SURGE BIN LEVEL SWITCH LOW |
| LT 1009 | 201 | LIGNITE SILO LEVEL TRANSMITTER |
| LT 2001 | 203-1 | DEVOLATILIZER SPENT DOLOMITE POT LEVEL TRANSMITTER |
| LT 2003 | 203-1 | GASIFIER SPENT DOLOMITE BED LEVEL TRANSMITTER<br>THRU LIC 2003 TO XCV 2132 |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE CO2 ACCEPTOR PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET SRC | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PT 2002 | 203-1 | DEVOLATILIZER DOLOMITE POT PRESSURE TRANSMITTER |
| PT 2007 | 203-1 | RECYCLE GAS PRESSURE TRANSMITTER |
| PT 2018 | 203-1 | REGENERATOR DISCHARGE PRESSURE TRANSMITTER |
| PT 2025 | 203-1 | GASIFIER D/P LINE PURGE PRESS XMTR |
| TE 2317 | 203-1 | REGENERATOR DOLOMITE DSCH TEMPERATURE ELEMENT<br>DOES TEMP VS FLOW PROVIDE DESIRED ACCURACY? |
| WI 2030 | 205 | ASH OUT HOPPER A WEIGHT IND |
| WI 2031 | 205 | ASH OUT HOPPER B WEIGHT IND |
| WR 2030 | 205 | ASH OUT HOPPER A WEIGHT REC |
| WR 2031 | 205 | ASH OUT HOPPER B WEIGHT REC |
| WSH 2030 | 205 | ASH OUT HOPPER A WEIGHT SW HI |
| WSH 2031 | 205 | ASH OUT HOPPER B WEIGHT SW HI |
| WT 2030 | 205 | ASH OUT HOPPER A WEIGHT XMTR<br>SEE WI+WR 2030 |
| WT 2031 | 205 | ASH OUT HOPPER B WEIGHT XMTR<br>SEE WI/WR 2031 |
| WT 2032 | 202 | LIGNITE HOPPER A WEIGH XMTR |
| WT 2033 | 202 | LIGNITE FEEDER B WEIGHT TRANSMITTER |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE HYGAS PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET IGT | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AIT 405 | 4.00-1-J | QUENCH TOWER GAS ANALYTICAL IND XMTR<br>SEE AJV 405 |
| AIT 406 | 4.00-1-J | QUENCH TOWER GAS ANALYTICAL IND XMTR<br>SEE AIT 405 |
| AIT 462 | 4.00-2-J | CAUSTIC & WATER WASH SCRUBBER GAS CO ANALYTICAL IND XMTR |
| AIT 463 | 4.00-2-J | CAUSTIC & WATER WASH SCRUBBER CO2 ANALYTICAL IND XMTR |
| AIT 505 | 5.00-1-J | 1ST STAGE QUENCH GAS CO ANALYTICAL IND XMTR |
| AIT 566 | 5.00-1-J | 1ST STAGE QUENCH GAS H2 ANALYTICAL IND XMTR |
| AJV 405 | 4.00-1-J | HYDROGASIFIER EFFL QUE GAS OUTL GAS ANALYSIS SCANNING VALVE<br>CHECK TYPE USED IGT HAS SPENT MUCH TIME ON GAS ANALYZERS |
| AJV 406 | 4.00-1-J | QUENCH TOWER GAS CHROMATOGRAPH SCANNING VALVE |
| FT 3079 | 3.00-1-J | FEED SLURRY PUMPS SUCTION FLOW XMTR |
| FT 668S | 3.00-3-J | SPENT CHAR SLURRY MIX DRUM DSCH FLOW XMTR<br>FE IS A VENTURI-QUESTION PROBLEMS |
| LT 321B | 3.00-2-J | HYGAS REACTOR LEVEL TRANSMITTER B |
| LTI 407S | 4.00-1-J | QUENCH SEPARATOR LEVEL IND XMTR<br>QUESTION INTERFACE |
| LWA 112 | 1.00-1-J | COAL LEVEL WEIGHT ALARM<br>DIRECT SCALEUP UNLIKELY |
| PDT 3089 | 3.00-2-J | HYGAS REACTOR D/P TRANSMITTER |
| PDT 3157S | 3.00-2-J | CYCLONE DIP LEG D/P XMTR<br>CONSIDER MASS FLOW AND TRANSPORT PROBLEMS |
| PDT 374 | 3.00-2-J | HYGAS REACTOR DIFFERENTIAL PRESSURE TRANSMITTER |
| PI 349S | 3.00-1-J | FEED BLOW DOWN DRUM PRESSURE IND<br>WILL DECANTER BE REQUIRED FOR SCALE UP |
| WIC 112 | 1.00-1-J | COAL WEIGHT INTEGRATOR CONTROLLER<br>DIRECT SCALEUP NOT LIKELY |
| WT 112 | 1.00-1-J | SIZED COAL WEIGHT BELT WEIGHT TRANSMITTER<br>DIRECT SCALE UP UNLIKELY |
| WY 112 | 1.00-1-J | COAL WEIGHT INTEGRATOR<br>DIRECT SCALEUP UNLIKELY |
| XD 1003A | 3.00-1-J | 3 UNLISTED DENSITY DEVICES<br>SLURRY DENSITY MSMT-LIST MFR AND SERVICE RECORD |
| XF 1012 | 3.00-1-J | 12 UNLISTED FLOW DEVICES<br>REVIEW FOR MASS FLOW |
| XL 1024B | 4.00-1-J | 24 UNLISTED LEVEL DEVICES<br>ANY INTERFACE PROBLEMS? |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SRC PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS

NONE FOUND

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SYNTHANE PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS

| DEVICE I.D. NO. | FLOW SHEET LCO | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| AR 239-1 | 02005G-4 | TWP METHANATOR GAS ANALYSIS RECORDER<br>SEE XX 109U |
| AR 240-2 | 02005D-4 | MEDIUM PRESS STEAM O2 ANALYTICAL RECORDER<br>INTERESTING APPLICATION-CHECK IF REQD ON SCALE UP |
| FIC 215 | 02005E-5 | ABSORBENT REGENERATOR INLET STEAM FLOW INDICATING CONTROLLER<br>CARRIED AS COMPARISON TO FIC 222-THIS WILL SCALE UP BUT FOR CONTROL DP SHOULD BE LINEARIZED |
| FIC 222 | 02005E-5 | ABSORBENT REGENERATOR GAS INLET FLOW INDICATING CONTROLLER<br>THIS TYPE OF DEVICE WILL NOT SCALE UP-CONTROL IS NOT THE BEST |
| LAH 401 | 04005A-4 | CHAR LOCK HOPPER HIGH LEVEL ALARM<br>PART OF PLL 401 |
| LAHL 413 | 04005A-4 | LP CHAR SLURRY TANK HIGH LEVEL ALARM<br>CHECK APPLICATION |
| LC 203S | 02005C-5 | DECANTER TAR LEVEL CONTROL<br>QUESTION TAR/WATER INTERFACE |
| LI 413 | 04005A-4 | LP CHAR SLURRY TANK LEVEL INDICATOR<br>CHECK APPLICATION |
| LIC 405 | 00462A-1 | CHAR SLURRY TANK LEVEL INDICATING CONTROLLER |
| LLH 402 | 04005A-4 | CHAR LOCK HOPPER HIGH LEVEL LIGHT<br>SUSPICION OF LEVEL PROBLEMS |
| LSH 402 | 00462A-1 | CHAR LOCK HOPPER HIGH LEVEL SWITCH<br>ANY PROBLEMS? |
| LSL 402 | 00462A-1 | CHAR LOCK HOPPER LOW LEVEL SWITCH<br>SEE LSH 402 |
| PDAH 202 | 02005A-4 | GASIFIER FLUID BED HIGH DIFFL PRESS ALARM |
| PDAH 204 | 02005A-4 | CHAR FLUID BED HIGH DIFFL PRESS ALARM |
| PDAH 259 | 02005A-4 | GASIFIER DISTRIBUTOR HIGH DIFF PRESS ALARM |
| PDAH 259A | 00462A-1 | GASIFIER DISTRIBUTOR HIGH DIFFL PRESS ALARM |
| PDAH 261 | 02005A-4 | CHAR COOLER DISTRIBUTOR HIGH DIFFL PRESS ALARM |
| PDAL 202 | 02005A-4 | GASIFIER FLUID BED LOW DIFFL PRESS ALARM<br>SEE PDIC 202 |
| PDC 259 | 02005A-4 | GASIFIER DISTRIBUTOR STEAM DIFFL PRESS CONT |
| PDI 2034 | 02005A-4 | GASIFIER FLUID BED DIFFL PRESS INDICATOR |
| PDI 2035 | 02005A-4 | GASIFIER FLUID BED DIFFL PRESS INDICATOR |
| PDI 205 A | 02005A-4 | CHAR FLUID BED DIFFL PRESS IND |

ERDA COAL CONVERSION INSTRUMENTATION REVIEW FOR THE SYNTHANE PROCESS
INSTRUMENTS WHICH ARE NOT ACCEPTABLE IN SCALED UP PLANTS (CONTINUED)

| DEVICE I.D. NO. | FLOW SHEET LCO | MEASUREMENT NAME / COMMENTS |
|---|---|---|
| PDI 205 B | 02005A-4 | CHAR FLUID BED DIFFL PRESS INDICATOR |
| PDI 254 | 02005A-4 | PRETREATER DIFFL PRESS IND |
| PDI 259 | 02005A-4 | GASIFIER DISTRIBUTOR PROCESS DIFFL PRESS IND |
| PDI 261 | 02005A-4 | CHAR DISTRIBUTOR DIFFL PRESS IND |
| PDIC 202 | 02005A-4 | GASIFIER FLUID BED DIFFL PRESS IND CONT<br>AT 1000 PSI 1400F-BED LEVEL MUST BE A PROBLEM |
| PDIC 204 | 02005A-4 | CHAR FLUID BED DIFFL PRESS IND CONT |
| PDIC 257 | 00462A-1 | GASIFIER FLUID BED DIFFL PRESS IND CONT |
| PDM 254 A | 02005A-4 | PRETREATER DIFFL PRESS XMTR |
| PDM 255 A | 02005A-4 | PRETREATER DIFFL PRESS XMTR |
| PLL 401 | 04005A-4 | CHAR LOCK HOPPER LOW LEVEL LIGHT<br>CHECK PROCESS AND APPLICATION |
| PM 267 A | 02005A-4 | PRETREATER PRESS XMTR |
| TR 245 | 02005D-4 | SHIFT CONVERTER TEMPERATURE RECORDER<br>TEMP ELEMENT NOT SHOWN-AT 1000 PSIG/800F VESSEL SIZE ON<br>SCALE-UP MAY REQUIRE SPECIAL THERMOWELLS |
| TRC 203 | 00462A-1 | GASIFIER DISTRIBUTOR TEMP REC CONT |
| XX 109U | 02005G-4 | 35 UNLISTED UNCLASSIFIED INSTRUMENTS<br>PROCESS SHOULD BE CHECKED-IS THERE SUFFICIENT INFO? |
| XX 114U | 00462A-1 | 39 MISC UNLISTED DEVICES<br>NO ANALYTICAL DEVICES SHOWN |