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MASTER

1.0 Introduction

This is a topical report covering an investigation by Stearns-Roger into several incidents of piping failure in the BI-GAS pilot plant. It includes decisions that have been made with regard to piping replacements and operating procedures that will be effected to avoid future failures. To that objective all piping systems have been reviewed. Because stress corrosion cracking has been found to be the culprit, only stainless steel systems are discussed in this report.

2.0 Background Information

2.1 Recent Failures

Two recent incidents of pipe failure were of concern:

- 2.1.1 A large circumferential crack was found in the gasifier outlet 8" pipe on July 31, 1980. This was near a weld and in an area of high stress.

Other areas of cracking in the same 8" gasifier outlet piping were found by checking the other points of calculated high stress. These cracks were also found near welds. The welds were at joints of Type 304 stainless steel pipe to chrom-moly (F-11) tees, wherein the weld was stress relieved as a code requirement. The cracks were in the 304 stainless in zones which were sensitized by stress relieving.

- 2.1.2 A crack near a weld in the 4" char cyclone outlet piping was found three weeks later on August 22, 1980. This also was in an area of high stress which was earlier inspected by ultrasonics testing (UT). The crack was not detected but likely was present.

2.2 General Problem of Stress Corrosion Cracking

2.2.1 Stress Corrosion Cracking (SCC)

When certain alloys are subjected to a combination of:

- a. stress of some critical level,
- and b. an environment of a critical concentration of certain ions dissolved in water. Then the material can fail by cracking.

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The threshold of stress required to produce such a failure can be well below the yield or design stress of the alloy. The coexistence of the above two conditions is all that is necessary for SCC to take place.

The time for SCC to become evident will depend on:

- a. stress level
- b. degree of sensitization
- c. temperature
- d. stress cracking ion concentration
- e. presence of condensate
- f. extent of temperature and stress cycling.

Conditions may exist which allow SCC to develop in a few hours or it may take years.

2.2.2 Sensitization

Stainless steel contains about 0.08% carbon. When it is heated, the carbon becomes mobile and migrates to the grain boundaries. Chromium will react with the carbon concentrated near the grain boundaries to form chromium carbide. This leaves a thin chromium depleted zone adjacent to the grain boundaries. This loss of chromium is called "sensitization". It weakens both the grain and the boundaries and makes the metal more susceptible to corrosion. SCC is greatly enhanced by sensitization.

The rate of sensitization depends on temperature. The extent of sensitization can thus be the same for metal heated to only slightly above 800°F as for the same metal heated to 1500°F provided it remains above 800°F for a much longer time. When a chrome moly steel such as P-11 (1¼% Cr, ½% Mo) is welded to type 304 stainless steel, and the weld is more than ½ inch thick, code requires stress relieving the weld. The pipes which failed by SCC were in this category. In stress relieving the weld the the 304 stainless steel will become sensitized in the vicinity of the weld.

2.2.3 SCC Susceptible Environments

When stress corrosion cracking was indicated in the present failures chlorides were immediately suspected. Chlorides, however, create only one of a number of possible types of ionic environments which can cause SCC.

Also, many metals are susceptible, to varying degrees, to SCC. The first to be so defined was brass cracked by ammonia. The OH^- ions of caustic, or solutions containing Cl^- ions can provide a critical environment for stainless steel.

General Electric has encountered similar problems with SCC in nuclear reactor systems made of highly sensitized 304 stainless steel. Their case was definitely not related to chlorides. Their findings, through the work of a task force, indicated their SCC to be caused by OH^- ions.

Three recent papers* indicate that cracking (similar to the BI-GAS failure) can be produced without chloride or caustic, provided as little as 0.8 ppm of added oxygen is present. It has been postulated that oxygen produces hydroxyl ion which is the contributory environmental ingredient.

Yet another stress cracking mechanism has been reported as a possible cause of intergranular corrosion in sensitized type 304 stainless steel. In this type polythionic acid corrodes the chromium carbide at the grain boundaries to form an intergranular type of failure. Generally it produces a multiplicity of cracks to some degree having a polygonal shape similar to shrinkage cracks in dried clay.

2.2.4 Metallurgical Options

Alloys resistant to SCC are:

(1) Stainless steels

To minimize sensitization, low carbon grades of stainless steel are available ("L" grades as 304L and 316L) wherein carbon content is limited to 0.035%. However, the low carbon reduces the allowable stress of the material.

Another approach has been to add an element to the alloy which has higher affinity for carbon than chromium does, but will be more soluble in the matrix. These are the stabilized grades types 347 and 321 in which Columbium

* STRESS CORROSION CRACKING OF WELDED TYPE 304 STAINLESS STEEL UNDER CYCLIC LOADING by J.N. Kass & W.L. Walker, NACE, #49, Atlanta, March '79

SCC of SENSITIZED AND QUENCH ANNEALED TYPE 304 STAINLESS STEEL IN HIGH PURITY WATER by Agarawal et al, NACE, #187, Houston, March '78

STUDIES OF PROTECTION METHODS FOR INTERGRANULAR STRESS CORROSION CRACKING OF TYPE 304 STAINLESS STEEL IN BOILING WATER REACTOR APPLICATION by A.J. Giannuzzi et al, NACE, #188, Houston, March '78

and Titanium are added. Columbium carbide is formed in type 347 and Titanium carbide in 321. These deplete carbide available to precipitate at the grain boundaries without reducing the alloy strength.

Type 347 and 321 stainless are resistant to polythionic acid or hydroxyl ion cracking but can be sensitized by exposure to high temperature for long periods. They would not be sensitized at 850°F which is near maximum for most BI-GAS piping. Type 347 can be acceptable at this temperature but is not immune to chloride stress corrosion cracking.

(2) P-11 piping (1¼% Cr, ½% Mo steel) is good for erosion but susceptible to general corrosion, but this can be allowed for by using thicker pipe. In evaluating P-11, corrosion has been found negligible in the offgas to the cyclones and down to the gas washer in the BI-GAS pilot plant.

(3) 20 cb is not adequate for stress at temperature.

(4) Inconel 800 or 825 are good but require long delivery.

(5) Inconel 600 is inadequate for stress at temperature and also has sulfidation susceptibility.

2.3 Detailed Examination of Current Incidents

2.3.1 Conditions of Failures

The July 31st gas line failure occurred during start up pressuring at 40 psig. The previous run was a long five day run. This had been followed by a twenty day shutdown.

During the shutdown, the affected lines were not heated and were opened allowing atmospheric oxygen to enter.

The through-wall crack was in an eight inch vertical, type 304 stainless steel line. It was just above the weld to a blinded F-11 (1¼% Cr, ½% Mo) tee which was used in place of a vertical to horizontal elbow. The bull of the tee was horizontal and the other run was pointed down and had a type 304SS Grayloc flange welded to it (the flange has a blind on it).

Three other cracks were discovered by UT (Ultrasonic testing). These were not yet cracked completely through the pipe wall. They were located at each end of the horizontal line near welds to F-11 tees.

On examining the line it contained a significant (unmeasured) amount of water. Although the exact origin of this water is uncertain, it was sampled and analyzed; results indicated it contained 4.45 ppm of Cl^- ion and had a pH of 8.1. It is not certain that this liquid represents conditions responsible for the crack. But if so it would rule out chlorides or polythionic acid (due to high pH) as the troublesome environment.

Failure took place where thermal expansion would exert a high cyclic stress. It was in the type 304 stainless steel pipe and continued around three quarters of the circumference parallel to and about one inch away from the weld joining the pipe to the F-11 tee.

In this case code required that the welding of the stainless pipe to the F-11 tee be stress relieved. This had been done during construction. Unfortunately this had highly sensitized the 304 stainless steel and made it especially susceptible to failure.

In addition to high stress due to process pressure and temperature, the different thermal expansions of the two dissimilar metals also produced localized cyclic stress at or near the cracks.

Locations in this gas piping system with expected lower stress were examined by UT but did not reveal any cracks. Since all the piping sees the same environment, this indicates that stress is a factor.

The gas piping involved was that from the gasifier to the char cyclones. After the first failure, as a precautionary measure the eight inch gas line from the char cyclone, including the four-inch branches at cyclone were also tested by UT. No cracks were indicated.

After this first gas piping failure the eight inch 304 stainless steel gas line from the gasifier to the char cyclone was replaced with P-11. This was based on the good apparent condition of the F-11 tees (which were retained) and also based on the fact that P-11 is not susceptible to SCC. The gas line after the char cyclone was not replaced since the UT examination revealed no defects.

After this first replacement was completed, a new startup was attempted. But on August 22nd, while in startup pressuring at 750 psig, another failure occurred. This was at a tee in a four-inch branch at the

char cyclone outlet, a point specifically tested by UT after the first failure. Post incident examination revealed a deeply corroded crack which must have been present but was missed in the UT examination.

2.3.2 Cause of Failures

Samples were submitted to Industrial Testing Laboratories and Argonne Laboratories. They reported intergranular type stress cracking. The 304 stainless steel was highly sensitized and the crack followed the grain boundaries without tendency to enter the grains. The cracks were typically branching type, initiating from the inside of the pipe.

The attached figure shows the location of the July 31st failure and photo-micrographs of the crack.

Although both laboratories concluded chloride stress cracking, when questioned, their diagnosis allowed the possibility of other types of environment.

More insight into the circumstances was gained by Patrick Dempsey, Stearns-Roger Chief Metallurgist who presented the case to about 200 participants at the Pittsburgh Gasification Conference. "THE PROPERTIES AND PERFORMANCE OF MATERIALS IN THE COAL GASIFICATION ENVIRONMENT" on September 9, 1980. Group response offered that General Electric had experienced similar cracking in their Boiling Water Reactors. In their case type 304 stainless steel cracked in a pure water environment (without chlorides or sulfides) containing as little as 0.8 ppm of oxygen.

Argonne Laboratories is continuing analysis of the failures. But, a tentative decision of failure of the above mentioned General Electric type was made - stress induced cracking enhanced by oxygenation of condensate during shutdown conditions.

The general cure for this condition is to prevent infiltration of oxygen during shutdown and avoid presence of liquid by keeping the temperature above condensation at all times.

Fortunately the corrective actions above will be a general fix for any of the mechanisms under suspect. Therefore, gasifier operation can proceed without waiting for the ultimate diagnosis.

SCHEMATIC OF GAS LINE

VIEW OF PIPE ARRANGEMENT

PHOTOMICROGRAPH:
OF THE FAILURE CRACK
SHOWING IT'S BRANCHING
TENDANCY.

PHOTOMICROGRAPH:
OF THE FAILURE CRACK
SHOWING IT'S TRANSGRANULAR
NATURE.

2.4 Review of Other SCC History in the Pilot Plant

There have been several other instances of suspected SCC in the pilot plant.

2.4.1 The expansion bellows in "A" car burner failed on February 25, 1979. "A" burner bellows was destroyed in the incident. The identical bellows of "C" char burner was then tested and SCC was found. The char burner bellows are subject to very high stresses. It was thought that chloride was coming from trichloroethylene used as a cleaning solvent. This source of chloride is unlikely due to the volatility of trichloroethylene.

2.4.2 A three-inch pressure relief valve outlet line of 304 stainless steel failed. This is an emergency relief from the gas line from the gasifier to the char cyclones (first of our two recent failures). The outlet discharges into the gas washer.

It failed, as in our current incidents by intergranular stress cracking on April 22, 1977, at a weld near an elbow. It was replaced with a new elbow and pup piece both of 304 stainless. This failed again on May 31, 1977. The material was again replaced with 304 stainless steel but 50 psig steam tracing was added. No further failures occurred, but the line was later replaced with alloy 800 also steam traced.

Phillips Petroleum, then manager of the BI-GAS project diagnosed the failure to be caused by polythionic acid. (See Per 23R-77 and Per 32-77).

2.5 Process Conditions and Environments

The chloride content of a particular coal is quite variable but remains within limits. The Rosebud coal used exclusively in this project has analyzed 50 to 200 ppm chlorine; the Rosebud char 75 to 400 ppm. The water feed to the spray drier is approximately 20 ppm chlorine. The Pittsburgh and Illinois coals, planned for future use in the project, are much higher in chlorine, from 0.4 to 1.0%.

Because of the low amount of chlorine currently fed (water with as much as 100 ppm is generally acceptable for use in hydrotesting pipe) it was thought that unless a mechanism for concentrating chlorides was present, it is unlikely that the current SCC is due to chlorine. No chlorine concentrating mechanism is evident in the BI-GAS pilot plant but internal discussion concerning prevention of chlorine buildup was generated.

A suggestion to monitor pH and/or chloride in all available sampling points in the plant was made. Sampling is suggested at the gas washer, the slag quench, the coal feed, the char feed, the water to the spray drier, the boiler feed water and the slurry to the spray drier. These would be especially helpful in establishing a threshold of chlorides so that it can be compared with the level when coals of higher chloride content are used.

It was reasoned that gaseous chlorides, in this typically reducing atmosphere, would probably be in the form of HCl. It was then further deduced that due to the solution of HCl in water most would be removed in the Gas Washer. And further downstream the Selexol unit would remove the last traces of HCl.

It was also further noted that failures downstream of the gas washer are of a "benign" nature. If a failure occurred downstream, hot gases would be retained in the gasifier-gas washer system by the normal pressure control valve. The retained atmosphere could then be vented safely to the thermal oxidizer thus by-passing downstream processing.

3.0 Corrective Actions

3.1 General

Revisions as presented below are to be implemented. Note that they do not make the plant risk-free with respect to future failures. The changes should bring the chance of additional failures within acceptable limits particularly considering the experimental nature of the pilot plant.

Note that the incidents here would be more prone to happen in a pilot plant with extensive down time between periods of operation. But, they do have application to full scale plant installations and point out necessary precautions.

3.2 Description of Revisions

All the stainless steel in the plant was identified and considered. Most of this can be grouped into "piping areas". Each piping area was discussed in terms of the important variables of SCC as presented in 2.2 above. For this particular plant these variables can be boiled down to extra stress due to thermal cycling, sensitization due to welds or high temperatures, condensation, and a medium for chloride ion, polythionic acid, and/or hydroxyl ion.

Although from the above discussion no conclusive evidence can be pointed to any particular environment being the culprit, stress corrosion (or induced) cracking is evident.

Therefore, the changes to be made as discussed below consider that the recent incidents were stress corrosion cracking, possibly caused by dissolved oxygen. Chloride SCC was not apparent in the recent incidents but is still a possibility and must be guarded against. Since condensation is a factor in Cl^- , polythionic acid, and OH^- SCC, a significant portion of the recommendations guard against condensation.

Only stainless steel piping is considered prone to SCC and therefore consideration was restricted to stainless lines. Product gas lines beyond the Combined Effluent Trim Cooler (E-601 A&B) were not considered since these are primarily carbon steel. Also they operate at temperatures below stainless sensitization and the gas will be free of chlorides.

Recommendations for prevention of SCC in terms of these variables were formulated. (The attached chart provides a summary).

a. Gasifier Outlet

This is the piping from the gasifier overhead to the char cyclone and from the char cyclone to the gas washer. The recent discoveries of SCC were in this system at points of high stress near welds. Stresses due to thermal cycling will be present. The system has many welds, including stainless to P-11. Condensation will definitely occur if cool off after shutdown is allowed. Runs of horizontal pipe and potential areas of condensate collection are present. Because of the combination of all potential factors favoring SCC it was decided to replace all this stainless steel piping with P-11. The F-11 tees have not shown significant corrosion in five years. Chrom-moly steel is generally considered subject to corrosion and therefore, monitoring for corrosion and steam tracing with heating during shutdown is recommended. The heat will prevent condensation and reduce cyclic stress by limiting the lower temperature range.

The P-11 pipe also provides a reduction in thermal pipe stress (about 23% less than type 304 stainless steel). And since there are no dissimilar materials cyclic stress extremes will be lower.

b. Coal and Char Feed Lines

The original 4" lines have been recently replaced with 1½" and 1" 304SS pipe. These lines have relatively thin walls and have not sensitized with welding. Also no stress relieving has been done on them. The service temperature is low so that sensitization will not occur. The lines are nearly vertical so condensation will not collect. They are flexible and not prone to high stress. These lines will remain in service. To prevent condensation the lines are to be kept dry on shutdown via draining and steam heating.

c. Coal and Char Sampling Stations

These are made of small 304SS pipe. They operate under the same conditions as the coal and char feed lines. Sampling is done only three times daily and the lines are well purged when sampling is completed so that condensate may not collect. Sensitization and stress is minimal for the same reasons as it was for the char and coal feed lines. These lines will remain in service but will be drained and purged on shutdown.

d. Recycle Gas Heater and Heated Recycle Gas Line to Spray Drier

The tubes in the heater are of 304SS and the line is of more resistant 316SS. The gas is heated to 1150°F in the heater, therefore both the heater tubes and gas line have been sensitized. Recycle Gas contains negligible chloride (< 20ppm) and has been dried to a dewpoint well below operating temperature (about 220°F at 800 psig or higher). During shutdown the heater and line are purged and kept in the purged condition thus avoiding condensation and atmospheric oxygen. (Note-checks will be required to assure that the purged condition atmosphere has a dewpoint below ambient temperature). During the five year life of the pilot plant there has been no evidence of SCC in the heater tubes or the line. The tubes and line will remain in service.

e. Water System for Gas Washer

The material is 304SS, but low temperature prevents sensitization. These lines will remain in service but will be fully drained and flushed at each shutdown.

f. Condensate from Fluid Bed Reactor K.O. Drum

This line is 304SS but it is not sensitized and does not contain chlorides. Thermal stresses will be minimal due to low temperature operation (less than 500°F). This line will remain in service.

g. Product Lines from Gas Washer and Alumina Filters

The temperatures are low (440°F) and the lines are all 304SS so sensitization due to stress relieving of welds between dissimilar metals is not a factor. Chlorides will not be present. These lines will not be changed.

h. Product Lines from CO Shift Feed Heater

The temperature (580⁰F) are below sensitization and no dissimilar metals are present (all is 304SS). Chlorides are absent. These lines will not be changed.

i. Product from CO Shift Reactor

The temperature is 825⁰F which is below sensitization for this 347SS line. Chlorides are not present. This line will not be changed.

j. Product from Sulfur Conversion and from A-601

These 304SS lines operate at 460⁰F so they will remain insensitized. Chlorides are not present. These lines will not be changed.

**TABLE OF DETAILED PIPING CHANGES
TO BE MADE**

LINE DESCRIPTION	PRESENT INSTALLATION	PROCESS CONDITION	BACKGROUND	CHANGES TO BE MADE	REASONS FOR CHANGE	CONTINUING SAFEGUARDS
1. 8" GG-4102-FG PRODUCT GAS LINE FROM GASTIFIER QUENCH SECTION TO CHAR CYCLONES AND 8" GG-4103-FG PRODUCT GAS LINE FROM CHAR CYCLONES TO GAS WASHER.	a. PIPE-304SS b. TEE-F-11 c. GRAYLOC HUBS- 304SS d. VALVES-P-11 e. SOME 4" PIP- ING SCH. 160, 304SS	850°F, 1500 psig	EXPERIENCED CRACKS RECENTLY AT WELDING OF 304SS PIPE TO P-11 TEES (SENSI- TIZED HIGH STRESS AREAS)	a. CHANGE 304SS PIPE TO P-11 b. KEEP F-11 TEES c. KEEP 304SS HUBS AT BLINDED TEE ENDS d. REPLACE IN-LINE HUBS WITH P-11 e. KEEP P-11 VALVES f. REPLACE 4" SCH. 160, 304SS WITH 4" SCH. 80, P-11	a. P-11 PIPE AVOIDS SENSITIZATION AND SCC b. F-11 TEES SHOW NO SIGNIFICANT GENERAL CORROSION c. BLINDED TEE ENDS NOT HIGH STRESS AREAS d. 4" SCH. 80 OKAY, P-11 HAS HIGHER ALLOWABLE STRESS & LOWER EXPANSION, SCH. 80 AVOIDS NEED FOR HEAT TREATING	a. HEAT TRAC- ING ON AL- WAYS EXCEPT FOR LINE INSPECTION & MAINTENANCE b. REMOVE LIQUID BY DRAINING & FLUSHING NOT EVAPORA- TION c. CHECK WALL OF P-11 PIP- ING RANDOMLY AT LEAST QUARTERLY
2. 1½" HA-3102 & 3-FG COAL FEED LINES & 1" HB-4101, 2 & 3 -FG CHAR FEED LINES	304SS	500°F FOR COAL AND 700°F FOR CHAR AT 1500 psig	ORIGINALLY BOTH 4". SCC NOTED IN CHAR BURNERS BUT LINES SEE MUCH LOWER TEMP. & STRESS THAN BUR- NERS	NONE	a. 70° MIN. SLOPE & SELF DRAINING - AVOIDS CORROSIVES LAYING AND CONCEN- TRATING IN LOW POINTS b. SMALL FLEXIBLE LINES AVOIDS HIGH STRESS c. PURGED & COOLED WITH GAS WHICH C1 REMOVED IN GAS PURIFICATION d. VALVES NOT PRONE TO SCC DUE TO FERRITE CONTENT & HIGH SAFETY FACTOR e. NOT SENSITIZED BY STRESS RELIEVING f. OPERATES BELOW 750°F SENSITIZATION TEMP.	a. AS a. ABOVE b. DRAIN & KEEP DRY AT SHUTDOWN
3. S-301 COAL SAMPLE STATION AND S-302 CHAR SAMPLE STATION	304SS	AS COAL & CHAR FEED LINES ABOVE	ADDITIONS TO ORIGINAL DESIGN. SUBJECT TO PRO- CESS ONLY WHEN SAMPLING, ABOUT THREE TIMES DAILY	NONE	a. SMALL APPENDAGES, NOT RESTRAINED TEMP. STRESS NOT A PROBLEM b. NORMALLY WELL PURGED	a. KEEP DRAINED & PURGED WHEN NOT IN USE
4. 10" CH-2106-GS COAL DRIER GAS FROM RECYCLE GAS HEATER TO SPRAY DRIER & HEATER COIL	LINE IS 316SS NO VALVES; HEATER COIL IS 304SS	1150°F, 1575 psig	NO PROBLEMS TO DATE	NONE	a. VERY LOW IN C1 b. OXYGEN EXCLUDED c. CONDENSATION AVOIDED	a. DON'T ALLOW LIQUID TO CONDENSE IN LINE b. KEEP PURGED AT SHUTDOWN
5. ALL OTHER GAS PIPING IN COAL DRYING SYSTEM	CARBON STEEL	500°F, 1575 psig	NO PROBLEMS TO DATE	NONE	a. CARBON STEEL RESISTANT TO SCC	a. NORMAL PAST PRACTICE OF ROUTINE CHECKING
6. WATER SYSTEM FOR RECYCLE GAS WASHER (V-202) and WATER SYSTEM FOR (PRODUCT) GAS WASHER V-501	a. V-202-CARBON STEEL b. V-501-304SS	500°F, 1525 psig	NO PROBLEMS TO DATE	NONE	a. 17 ppm C1 IN V-501 SYSTEM, V-202 SYS- TEM SHOULD BE LESS c. CARBON STEEL NOT PRONE TO SCC	a. FULLY DRAIN AND FLUSH WITH CITY WATER AT SHUTDOWN b. FULLY DRAIN & REFILL TO START UP
7. 1½" GC-8101-FF CONDENSATE LINE FROM V-810 TO V-502	304SS-20 FT CLOSEST TO V-810. REST IS CARBON STEEL	500°F, 1415, psig	NO PROBLEMS TO DATE	NONE	a. 304SS NOT SENSI- TIZED BY HEAT TREATMENT b. OPERATES BELOW SENSITIZATION TEMP. c. CONDENSATE FROM GAS LOW IN C1 (REMOVED IN V-501 & SELEXOL)	a. NORMAL PAST PRACTICE OF ROUTINE CHECKING
8. 4"-GG-6101-FF GAS LINE FROM V-501 TO V-601 A&B, 4"-GG-6102-FF GAS LINE FROM V-601 A&B TO H-601 AND 3"-GG-6108-FF GAS LINE FROM V-601 A&B TO V-603	304SS	440°F, 1500 psig	ONLY V-601 A BEING RUN. H-601 (CO SHIFT FEED HEATER) NOT IN USE	NONE	a. a AS IN a IN 7 ABOVE b. b AS IN b IN 7 ABOVE c. CHLORIDES SCRUBBED OUT IN V-501	a. AS IN 7 ABOVE
9. 4"-GG-6103-FF GAS LINE FROM H-601 TO V-602	304SS	580°F, 1500 psig	H-601 AND V-602 (CO SHIFT REACTOR) NOT IN USE	NONE	SLIGHTLY HIGHER OPERA- TING TEMP. BUT 7,8 ABOVE APPLY	a. AS IN 7 ABOVE
10. 4"-GG-6104-FH GAS LINE FROM V-602 TO A-601	347SS	825°F, 1500 psig	NOT NOW IN USE	NONE	a. 347SS STABILIZED - NOT SENSITIZED AT 825°F b. C1s SCRUBBED OUT IN V-501	a. AS IN 7 ABOVE
11. 3"-GG-6109-FF GAS LINE FROM V-603 TO A-601 AND 4"-GG-6105-FF GAS LINE FROM A-601 TO E-602 A&B	304SS	GG-6109 460°F GG-6105 BELOW 200°F BOTH 1500 psig	V-603 NOT IN OPERATION. E-602B - RECENT ADDITION. A&B ALTERNATELY ON-STREAM OR STEAM PURGED TO REMOVE NAPHTHALENE COATING	NONE	AS 7, 8 ABOVE	a. AS IN 7 ABOVE

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