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From: W. K. Woods

100 AREAS TECHNICAL ACTIVITIES REPORT - ENGINEERING

MAY, 1947

CORROSION AND BLISTERING - W. K. Alexander, C. P. Cabell, R. A. Rohrbaugh

Summary

There were no cases of unusual blistering during the month of May.

Severe pitting of the rear Van Stone flange of Tube 1252-F prompted an extensive examination of rear Van Stone flanges in the B Pile. The flanges at the fringe of the pile were found to be more severely corroded than those in the center. Pits estimated to be 0.020 inches in depth were found on flanges in the 0.140-inch orifice zone, and up to 90% of the flange area showed evidence of corrosion.

Compression tests on jacketed lead slugs fabricated in the 300 Area show that these slugs are quite satisfactory for use in process tubes.

A project has been requested for construction of Van Stone flange test units in the X Sample Room of the D Pile, using irradiated process water.

Work on the problem of the discharge of stuck slugs has demonstrated that it is inadvisable to back up the rear flanges of a tube before going to high pushing forces, and has indicated the advisability of removing the lead slugs before using pushing forces above 4000 pounds.

Details

There were no cases of severe or unusual blistering during the month of May. Given below is a compilation of the corrosion and blistering data taken during the month:

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Tube #	Type	Power MD	Exposure Days	Blistered				Corr. Rates (Mils/mo.)	
				OK	Sl.	Mod.	Ext.	Ave.	Max.
2480-B	Corr.	61.2	371 Oper. 418 Down 798 Total	2	24	9	0	0.05	0.09
								0.02	0.04
2184-D	Corr.	25.6	154	4	27	1	0	0.03	0.04
2875-D	Reg. Disch.	25.9	147	2	29	1	0	--	--
2385-F	Papoose	44.3	356	4	25	3	0	--	--
3669-F	High Den. Reg. Metal	24.9	203	8 3	19 2	0 0	0 0	--	--
3678-F	High Den. Reg. Metal	24.9	203	8 2	19 3	0 0	0 0	--	--

Van Stone Flange Inspection

The rear Van Stone flange which was removed from Tube 1252-F during April was removed from the basin and examined for corrosion. It was found to be severely pitted with large deep pits. The maximum depth was estimated to be at least 50% of the tube wall thickness.

The rear Van Stone flanges of twenty-nine tubes were inspected at 100-B area on May 27. Listed below is a more or less qualitative summary of these inspections. The figures are only estimates from visual inspection. The nomenclature H and C refers to tubes in the inner and outer portions of the orifice zone, respectively.

Orifice Zone	Tube #	Max. Depth	Ave. Depth	% of flange Attached	General Appearance
240-H	2475	5 mils	5 mils	25	Pretty good
240-H	2484	5 mils	5 mils	30	Fair
240-C	2491	10 mils	5 mils	50	Fair
175-H	2492	10 mils	5 mils	60	Not too good
175-C	2494	15 mils	5 mils	75	Poor
140-C	2496	20 mils	5 to 10 mils	90	Bad
240-H	2980	5 mils	5 mils	20	Pretty good
240-H	3375	5 mils	5 mils	20	Fair to good
240-H	3384	5 mils	2 mils	2	Good
240-C	3289	5 mils	3 mils	25	Fair
200-C	3291	10 mils	5 mils	50	Not too good
200-H	3389	15 mils	5 to 10 mils	50	Poor
175-H	3391	15 mils	5 mils	60	Poor
140-H	3394	15 mils	5 to 10 mils	75	Pretty poor
175-C	3693	20 mils	5 mils	75	Some pretty bad pits
175-H	3789	15 mils	5 to 10 mils	75	Poor
140-C	3896	20 mils	5 to 10 mils	75	Bad
240-C	3982	10 mils	5 mils	50	Fair
200-H	3983	10 mils	5 mils	75	Poor

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Van Stone Flange Inspection (continued)

<u>Orifice Zone</u>	<u>Tube #</u>	<u>Max. Depth</u>	<u>Avg. Depth</u>	<u>% of Flange Attacked</u>	<u>General Appearance</u>
240-C	4175	15 mils	5 mils	50	Poor - small deep pits
200-C	4183	10 mils	5 mils	25	Fair
175-H	4184	10 mils	5 mils	25	Fair
140-H	4191	20 mils	5 to 10 mils	80	Bad
175-H	4275	10 mils	5 to 10 mils	60	Poor
175-C	4386	15 mils	5 mils	50	Poor
175-C	4475	10 mils	5 mils	60	Poor
140-H	4483	15 mils	5 to 10 mils	75	Bad
140-C	4675	20 mils	5 to 10 mils	75	Bad
140-C	4688	20 mils	5 to 10 mils	90	Bad

The above figures are in no way intended to be a quantitative measure of the depth of pitting but should serve to give a relative comparison of the extent of the attack.

Tests were started in the 100-D Flow Laboratory to determine if it would be feasible from a pitting standpoint to leave the B Area pile in a stagnant condition. The experiment consists of six Van Stone assemblies with the following solutions: 1. 0.5% Sodium Chromate, 2. 5.0% Sodium Dichromate, 3. 0.5% Sodium Dichromate, 4. 0.05% Sodium Dichromate, 5. 50% Calol, 6. Process water. These assemblies are made up in the usual manner with standard process tubes, gun barrels, gaskets and nozzles. There are the two regular stainless steel pieces in the nozzles and one lead and one perforated aluminum in the tube.

Calculations were made to determine the temperature rise which might be expected in tubes in the 0.240-inch, 0.200-inch, 0.175-inch and 0.140-inch orifice zones at 105-D if smaller orifices were substituted. The maximum slug surface temperatures which might be expected under various film conditions were also calculated. This information was used in preparation of a production test on the subject.

Compressive Strength of Lead Dummy Slugs

Compressive tests were made on three groups of aluminum-jacketed lead slugs which were fabricated by the "P" Department. Local fabrication of lead slugs will be necessary in the immediate future because of a shortage of supply.

All slugs submitted in the last group appeared to have sufficient strength to be used in the pile. This will be confirmed in June by an exhaustive series of tests on the slug design which will be selected as standard by the "P" Department.

Hydraulic Leak Tester for Process Tubes

At the request of the "P" Department a test was made to see if the hydraulic leak tester for process tubes could be used at 200 pounds gas pressure (the

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recommended operating pressure) with only 80 pounds water pressure available. The proposal was to fill the tube with water at 80 pounds pressure, then apply 200 pounds gas pressure. It was found that expansion of the system caused the water level in the tester to fall below the bottom of the gage glass.

A new type leak tester, employing two sight glasses in series, was suggested. Before this is built we plan to test the amount of water leakage which can be measured by the present tester at 80 and at 200 pounds/in² operating pressure. We will also investigate the time required for suitable tests at the lower pressure, and correlate this with the expansion of the water in the tube caused by heat given off from the slugs.

Chattering

The long-term chattering test is continuing in the flow laboratory at 105-D.

Several special pieces, lead weighted, were received from the 300 area, but we have not had an opportunity to test them for chattering.

It is now believed that special-request samples which will be used between uranium pieces should have a compressive strength of 8000 pounds, which at this time appears to be the maximum force which will be exerted on a process tube. (Precise value of this figure will be set after the tensile strength of a process tube is measured.) It appears that this strength can be obtained by use of an aluminum supporting tube 1.00" I.D. and 1.36" O.D.

Van Stone Flange Test Units

A project was taken out during the month for the construction of a "hot flow laboratory" to be installed in the X sample room at 105-D for the purpose of measuring the corrosion of exit Van Stone flange by process water at elevated temperatures. By drawing the water from the discharge face of the pile it will be possible to reproduce pile conditions quite closely.

As a control laboratory, to evaluate the effect of pile irradiation on corrosive properties of process water, a duplicate installation will be made in the flow laboratory at 105-D, employing process water drawn from the charge-face risers and heated in the flow laboratory.

Process design for the new installations was completed during the month and the general layout turned over the Project Engineering for final layout and shop drawings.

On the rear face, 1-inch stainless steel lines will draw process water from the sixteen spare "pigtail" outlets located, four to a header, on headers 20 $\frac{1}{2}$ ", 22 $\frac{1}{2}$ ", 24 $\frac{1}{2}$ " and 26 $\frac{1}{2}$ " near tube row 88. These are unchilled headers. The 1-inch lines will feed into a 3-inch stainless steel header 35 feet long, which will carry the water to the wall separating the discharge area from the X Sample Room. At this point a 2 $\frac{1}{2}$ -inch stainless steel pipe 6 feet long will be installed through the hole already provided in the wall. On the sample room

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side of the wall, a 2½-inch valve will be installed as a safety shut-off.

Flow through this pipe, as well as through the entire system, will be by gravity. Our calculations supported by tests on small-size piping already installed, indicate that this system can deliver 50 gpm to the sample room with a head loss of about 2½ feet of the 40 feet of head available. The hold-up time, at 50 gpm, will be 24 seconds.

Layout for this piping has been approved, and it is now being fabricated in the 105-D Shops. It is hoped that sufficient shut-down time will be available to install it on the discharge face at 105-D during June.

A detailed design of the equipment in the X Sample Room is now being made by Project Engineering. Our proposal is as follows:

The water from the 2½-inch valve will be split into two streams. One stream will pass through a control valve, then flow through 1½-inch stainless steel pipe to four test units. Each unit will consist of about 12 inches of process tubing supported in a short section of discharge gun barrel by a Van Stone flange backed up by a rear-face nozzle. The assembly will contain two stainless steel pieces and a lead piece, arranged in the normal manner. Water will enter the unit through a special packing gland, pass through the tube in the normal manner, and flow out through a standard "pigtail" connection.

These four test units will be arranged in parallel, with a flow of about 6 gpm each. Temperature will be measured by a suitable element connected to a recorder. The temperature for these four units will be about 30°C.

The four units above will utilize one-half of the water available. The other half of the water will pass through a heat exchanger which can be operated for various outlet temperatures up to 100°C, and then flow to four test units similar to the other bank.

The heat exchanger will consist of 24 square feet of surface, provided by five eleven-foot sections of 1½-inch stainless steel pipe mounted in 2½-inch Schedule 80 iron pipe, or by a suitable tube-bundle type exchanger.

Pressure drop through the heat exchanger will be about 11 feet; through the auxiliary piping about 4 feet, and through the test units about 6 feet. This gives a total pressure drop from discharge-face header to sewer of about 24 feet out of 40 feet of head available.

The hold-up time through the sample room equipment will be about 20 seconds. Based on these figures, West has estimated that the intensity of radiation will not exceed 900 mr/hr at 1 foot, and has suggested the use of a shielding wall consisting of 4½-inch of lead.

The discharge water from this entire system will be piped into the process sewer in the X Sample Room. We have found that the sewer will easily handle an additional load of 50 gpm, provided the baffle plate in the outlet is bypassed. Mr. McCue has suggested that we run our line through the baffle

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plate, in order to obtain the required capacity without breaking the air-seal.

The steam required for this system will be supplied by a 225 pound/ sq. inch line which is available about 100 feet away. It will be piped into the sample room through the opening containing the ventilating louver.

Another eight-unit system will be set up in the flow laboratory at 105-D, quite similar to the installation in the I Sample Room. Two heat exchangers which were used at Hanford C&K are available, and it is believed that they will probably be suitable. Since ample head is available, pressure drop through the system will be of no concern.

Discharge of Stuck Slugs - Problem Assignment No. 7-P

A problem assignment was taken out during the month to investigate various aspects of the stuck slug problem. The background for this assignment was covered in last month's report. A number of tests were run this month.

It was found that it will not be advisable to attempt to support a tube by backing up the rear flanges, as had been recommended by the Technical Department in 1945. When 6000 pounds pressure was applied under such conditions, the Van Stone flange pressed against the ring inside the rear nozzle and crimped inward, closing the opening to such a point that it was not possible to pass a slug through the tube. In addition, the tube lodged firmly in the gun barrel and it was necessary to hammer it out.

It is generally agreed that it will be desirable to remove the lead slugs upstream from a stuck piece before applying pushing forces above 4000 pounds. We feel, however, that it would be of interest to determine what increase in pushing force would result from the mushrooming of a lead slug. While the tests are not complete, enough information has been developed to show conclusively that serious results might follow.

Two process tubes were actually ruptured by supporting a single-canned lead slug in them and applying forces of 8500 pounds. (This would represent the worst condition, since the tube was not supported by graphite or a gun barrel.) Under these conditions, 2000 pounds force was required to move the lead slug in the tube. When the non-deformed section of the tube was inserted in a gun barrel it was impossible to push the slug through the tube into the gun barrel and it was also impossible to push the tube, containing the slug, through the gun barrel. If such a condition arose in the pile it might be necessary to remove the rear gun barrel to clear the tube, and this would probably result in a loss of the tube position.

Measurements were made of the compressive strength of various members of the tube system to aid in the eventual establishment of maximum allowable pushing forces. Tubular perforate aluminum dummies failed at 12,000 pounds; a process tube failed at 7200 pounds, and under a pressure of 40,000 pounds a MZG uranium slug mushroomed (at the aluminum cap) until it would not pass a process tube. At 3500 pounds pressure, applied by a perforated slug on the weld, there was no expansion of the uranium slug.

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An examination of Tube 1252-F showed that there was no external blister on the tube after having had a slug stuck in it to such an extent that 4000 pounds were required to push it.

GRAPHITE EXPANSION - E. R. Lewis, J. T. Carleton, J. C. Chatten

Summary

Marked increases in the amount of gun barrel binding have been observed for tubes in the D Pile.

Tests on the one-tube mock-up indicate the possibility that difficulty may be encountered in discharging standard slugs from the top central tubes of the D Pile after an additional increase of 50% in the amount of graphite expansion, because of fracture of the graphite near the ends of the gun barrels.

Details

Eleven tubes at D Pile were jacked in and out for measurement of the gun barrel gun clearance. Two tubes, 3959-D and 4474-D, which had moved freely during tests in January 1947 were found to bind so that their clearance could not be measured. The gun barrel gun-clearances of the other 9 tubes were found to have decreased between 1/32 and 6/32 inch over a period of 4 1/2 months.

One-Tube Mock-Up

To forecast the possible results of continued expansion of the graphite, a one-tube mock-up was designed and built. This included the first graphite block, the gun barrel, the thermal block, the cast iron donuts and a section of process tubing. These were held in place by a framework which was provided with adjustable brackets to move or restrain the movement of the gun barrel, graphite block and thermal block. Only one graphite block was included because it was felt that the main difficulty would be encountered at the edge of the pile where the change in slope was the greatest.

The first series of tests was run in May. These tests were intended to give a rough idea of the type of failure of the graphite or the gun barrel and the probable amount of graphite expansion before failure occurred. Stresses were applied in several different ways to simulate different possible pile conditions.

Table I gives the conditions of each test, while Table II gives the results of the tests when the inner ends of the graphite blocks were raised to simulate progressive expansion of the graphite.

TABLE I - CONDITIONS OF TESTS

<u>Test</u>	<u>Thermal Block</u>	<u>"Outer" End of Graphite</u>	<u>Compression of Graphite</u>
1	Omitted	Held down	By screws of mock-up frame
2	Resting on gun-barrel	Not restrained	No
3	Resting on gun-barrel	Held down	No

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TABLE I - CONDITIONS OF TESTS (continued)

Test	Thermal Block	"Outer" End of Graphite	Compression of Graphite
4	Held down	Not restrained	No
5	Held down	Not restrained	By clamps to simulate roof weight
6	Held down	Not restrained	By clamps to simulate roof weight

TABLE II - RESULTS OF MOCK-UP TESTS

Test Number (See Table I)	1	2	3	4	5	6
Slope of graphite block when 1.490" x 8" probe sticks (in/ft)	.153	.229	.183	.262	.209	.337
Slope of graphite block when 1.485" x 8" probe sticks (in/ft)	.221	.315	.251	.364	.448	.494
Slope of graphite block when 1.480" x 8" probe sticks (in/ft)	.425	.870	.455	.512	.657	.653
Slope of graphite block when 1.475" x 8" probe sticks (in/ft)	.541	1.17	.503	.512	.715	.864
Slope of graphite block when 1.470" x 8" probe sticks (in/ft)	.614	1.22	.503	.512	.715	.926
Slope of graphite block when 1.460" x 8" probe sticks (in/ft)	.634	—	.503	.512	.715	1.085
Slope of graphite block when 1.450" x 8" probe sticks (in/ft)	.634	—	.538	.624	.715	1.142
Slope of graphite block when 1.440" x 8" probe sticks (in/ft)	.701	—	.608	.624	.715	1.203
Slope of graphite block when graphite first fractured (in/ft)	.541	—	.503	.512	.715	—

The slope of the first graphite block at Tube 4674-D is about .35 in/ft. at present.

In test Numbers 2, 5 and 6 the gun barrel was bent and restricted the passage of the shorter probes. The longer probes were all stopped at the end of the gun barrel by the curvature of the process tube. The graphite block which fractured in test No. 5 did so two feet from the end, indicating a flaw at this point. All other blocks fractured by splitting and cracking around the end of the gun barrel.

The above tests give rather widely varying results, but several conclusions may be drawn from them.

1. The gun barrel will probably not break as the graphite expands, although it may bend and gradually restrict the passage of the slugs.
2. The process tube will probably not break although fracture of the graphite may distort it enough to prevent discharge of slugs.
3. There is danger of regular sized slugs sticking at the ends of the gun barrels of the worst tubes after the graphite has expanded 50% more than at the present time at D Pile.

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The configuration of the gun barrels in the piles is believed to be an indication of the forces exerted by the donuts, thermal block and first graphite block. Careful manometer traverses of the gun barrels have not been accurate enough to ascertain the exact slope of the gun barrel near its end, so an instrument is being designed for this purpose. Deflection data from the manometer traverse coupled with slope readings at various points will probably give an accurate enough picture of gun barrel deflection to determine how the gun barrel is stressed. This will in turn permit a better evaluation of the amount of expansion of the graphite required to cause a tube failure which will prevent discharge of slugs.

IRRADIATION STUDIES - S. S. Jones

Summary

The water rates in the tubes with thermocouple slugs were reduced in order to minimize chattering of the thermocouple leads; this effected an anticipated rise in tube outlet temperature and in thermocouple reading. Following the change in poison pattern on May 20th the A rod was not inserted as far into the pile, with the result that the thermocouple in Tube 2679 read 8°C. higher than formerly and is now reading somewhat higher than the thermocouple in Tube 1367. Readings have also increased because of a rise in river water temperature. Month end readings were 117° and 122°C. for Tubes 1367 and 2679, respectively.

Details

Measurement of Slug Axial Temperature: The orifices on tubes 1367 and 2679, which are loaded with the thermocouple slug assemblies, were changed from 0.240" diameter to 0.175". This was done to reduce the water flow rate through the tubes and thereby decrease the wear of the 1/4-inch diameter tubing that holds the thermocouple wires.

On May 14 the thermocouple lead wires were connected to the outer couple in tube 2679, which is 3 inches out from the bottom of well or 1 inch inside the end the uranium slug. The temperature of the slug at this point, at Pile equilibrium was 107°C, compared with a local water temperature of 35°C. and a temperature at the bottom of the hole of 110°C. The corresponding temperature, obtained in a heat transfer mock-up of a heated slug cooled at the ends, is 88°. This effect can be explained in part by the Wilkins effect which postulates the heating of the end of a slug that is exposed to high radiation flux without the shielding effect of an adjacent slug.

The slug axial temperatures under equilibrium conditions are shown in Table I. It is interesting to note that with the new poison pattern of May 20 the No. A horizontal control rod has been operated considerably further out where it does not affect the No. 2679 tube. This has produced an increase in the tube temperature of 12°C. and caused it to exceed that of tube 1367.

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TABLE I - SLUG AXIAL TEMPERATURE

Tube No. Date	1367 May 6	2679	1367 May 13	2679	1367 May 27**	2679
Exposure - <u>High</u> <u>DATE</u> Adj. ton.	180	46.8	189	57	210	77.5
Test Duration - weeks	16.71	4.29	17.71	5.29	19.71	7.29
Slug Axial Temp. °C.	116	110	118	107*	117	122**
Inlet Water Temp. °C.	11.1		11.8		14.6	
Local Water Temp. °C.						
from adjacent tubes	29.1	29.1	30.0	29.9	31.9	32.4
from test tube	33.6	33.8	34.4	34.9	36.1	38.2
Slug Temp. above Local Water (Δt_w)						
based on adj. tubes	86.9	80.9	88.0	77.1*	85.1	89.6
based on test tube	82.4	76.2	83.6	72.1*	80.9	83.8
Local Water Temp. above Inlet Water (Δt_w)						
based on adj. tubes	18.0	18.0	18.2	18.1	17.3	17.8
based on test tube	22.5	22.7	22.6	23.1	21.5	23.5
Ratio ($\Delta t_w / \Delta t_w$)						
adj. tubes	4.82	4.50	4.82	4.26*	4.92	5.00
test tube	3.66	3.36	3.70	3.12*	3.76	3.56

* Outer thermocouple, one inch from end of uranium slug?

** A-Rod at 140 inches out rather than 50-70 inches where it has been since the charging of tube 2679.

Water Flow Through Special Loadings: The Number 2 Flow Laboratory Tube at 105-F was equipped with sensitive Haise pressure gages for reading the orifice pressure and the upstream and downstream pressure of the process tube. The header pressure was read from a standard 0-400 psi gage. The header pressure was varied by throttling the header valve, and the flow was determined by measuring the time for an increase in level in Number 8 Condensate tank which had previously been calibrated.

The flow for two header pressures and various orifices was determined for the tube loadings shown in Table II and the resulting flow data are shown in Table III.

TABLE II - TUBE LOADING

Standard Dummy Charge	Charge in Tube 1367-F	Charge in Tube 2679-F
2 stainless steel	2 stainless steel	2 stainless steel
1 lead	1 steel *	1 steel *
8 perforated	7 perforated	7 perforated
2 lead	3 steel *	3 steel *
3 perforated	19 perforated	19 perforate, modified **
---	1 thermocouple slug	1 thermocouple slug

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TABLE II - TUBE LOADING (continued)

Standard Dummy Charge	Charge in Tube 1367-F	Charge in Tube 2679-F
34 solid aluminum	17 stainless steel	17 stainless steel
4 perforated	4 perforated	4 perforated
2 lead	2 lead	2 lead
6 perforated	6 perforated	6 perforated
1 lead	1 lead	1 lead

- * Aluminum jacketed steel slugs with a 5/16-inch diameter hole in center for passage of 1/4-inch diameter thermocouple tube.
 ** The 6th and 15th perforated slug in this group of 19 slugs, numbering from the downstream end, were replaced with solid aluminum slugs which had a 5/16-inch diameter axial hole.

TABLE III - FLOW RATES FOR SPECIAL LOADINGS

Tube Charge	Header Pressure	Orifice Dia. in.	ΔP Tube Psi	ΔP Orifice Psi	Flow gpm
Std. Dummy Charge	341	0.240	164	162	20.5
1367	217	0.240	105	103.7	16.1
	342	0.240	130.6	189	21.9
	341	0.240	130.9	189	22.0
	218	0.240	85.8	121	17.1
	342	0.200	91.5	244	17.9
	227	0.200	61.6	162	14.3
	342	0.175	65.5	273	14.9
	222	0.175	43	179	11.8
	342	0.140	34.2	304	10.5
	213	0.140	22.3	192	8.2
2679	342	0.240	133	182	21.5
	174	0.240	72.2	94	14.7
	342	0.175	62.5	270	14.8*
	176	0.175	38.1	139	10.3
	342	0.140	38.9	305	10.5*
	175	0.140	15.6	156	7.2

*These values calculated from pressure data and logarithmic flow chart.
 Note: ΔP for tube is measured from nozzle to nozzle; ΔP for orifice is measured from header to Panellit connection.

Steel Shielding Slugs: Twenty-four steel slugs are being machined by 300 Area maintenance to the dimensions of 6 inches long by 1.36 inches diameter.

Thermocouple Irradiation: Further heat transfer data across the slug-to-dry tube annulus has been obtained and will be reported as soon as the data are correlated. Two stainless steel solder baths have been made for use in a standard aluminum can in a process tube.

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 Technical Department

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