INTERIM REPORT--IMPROVED REAR FACE
PIGTAIL ASSEMBLY

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INTRODUCTION

This interim report is being issued to provide management with an up-to-date picture of development efforts on rear face slip joint fittings. Particular emphasis is given to the problem of pigtails failure at D and F Reactors. These existing fittings are starting to fail apparently due to a combination of pitting corrosion and fatigue cracking. Two serious ruptures have already occurred on the 105-D and F Reactors respectively, causing a total of two lost time outages. Detailed examinations of these fittings are being conducted by J. H. Hoage and W. W. Porter of Plant Engineering and it is an FEO recommendation that these fittings be replaced at the earliest feasible opportunity.

Coupled with this urgent situation is the fact that approximately three months lead time must be allowed for procurement of replacement fittings (if they are purchased off-site) and that development efforts on new fittings have not undergone sufficient on-and-off-pile testing to be considered complete. In addition future reactor improvement programs for increasing production envision overboring of the crossheader Parker fitting and use of enlarged pigtails it is an economic must to incorporate these increased dimensions in any permanent adapter fitting design.

RECOMMENDATIONS

Table #1 presents a comparison of the various pigtails assembly alternatives which now appear available. To give a basis for comparison the following assumptions have been made:

1) Lost production is worth $30/MWD=approximately $30/shutdown minute.
2) Reactor levels are 1500 MW.
3) That overboring of Parker fittings and enlarged pigtails will become a reality.
4) That an "O" ring type of slip joint seal can have a three year useful life.
5) An unscheduled outage which cannot be substituted for a planned outage is a loss of four shifts of production.
6) That external corrosion of pigtails can be essentially eliminated.

Based upon these assumptions and comparing costs totals in Table #1 the following facts are pertinent:

1) Two unscheduled lost production outages mark the break even point between waiting to establish Parker fittings and pigtails dimensions so that crossheader adapter fittings need only be changed once and proceeding on an interim replacement basis.

2) If pigtails must be replaced prior to overboring the crossheader Parker fitting, no advantage is gained by shifting the thermocouple to its new location—indeed production would be lost.

3) There are real dollar benefits to be realized if the crossheader Parker fitting overboring can be done concurrently with any whole or piecemeal replacement of pigtails because much of the cost of this operation is due to getting pigtail
adapter fittings on and off the reactor. This would seem to provide added incentive for A and E., FEO, and Processing personnel to fully evaluate the results of such overboring as soon as reasonably possible and to establish the design of such overboring.

4) The initial cost of fittings even if they should have to be discarded is nominal when compared to other factors.

Based upon these four facts the following action is recommended at this time:

1) A complete set of interim replacement fittings be procured for reactors in danger of immediate pigtail failure. This should consist of a pigtail with an "O" ring adapter welded to it and a straight barstock pigtail to crossheader adapter. This assembly (see sketch #1) would be the easiest fitting to get on and off the reactor and would provide for the easiest maintenance of "O" rings. It is felt that even if this adapter is never used it is the purchase of low cost insurance. With such fittings available it is further recommended that no replacement program be initiated until the start of the second unscheduled lost time outage resulting from pigtail failures in the hope that Parker fitting overbore and permanent pigtail adapter fittings can become a reality before such outages has eliminating one extra change over of fittings on the reactor. Based upon the experiences obtained with the 900 fittings installed at B, D, DR, and F Reactors to date it is felt that three years of useful life can be obtained with this assembly before "O" rings must be replaced.

(Note: The 211 zone temperature pigtails which were installed less than two years ago or the presently installed slipjoint pigtails need not be replaced at this time.)

2) To establish adapter fitting and pigtail dimensions at the earliest date analysis and development efforts must be expedited. This should include a determination of the affect of overboring upon (a) boiling propagation (TA-1 limit), (b) vibration, and (c) temperature sensing accuracy for elements located close to the crossheader.

This effort should also include a thorough analysis of the effect of increased flow upon the existing crossheaders considering of such items as:

a. Present wall thickness and strength of existing pipe material.
b. Corrosion and erosion rates—present and predicted future.
c. Adequacy of present supports.
d. Condition of welded joints where the Parker fitting joins the crossheader.
e. Vibration characteristics and accompanying stress effect with increased flow.

Further, the effort should include the development of proper tools to permit controlled overboring so that a leak proof seal may be attained with a minimum of outage time.

DISCUSSION

I. Present Status of Development

J-1 Slip Joint Assemblies
A study of Table #2 shows that approximately 900 J-1-type assemblies have been installed on B, D, F, and DR Reactors and that some of these assemblies have been installed for over a year. To date the only reported leaker removed from this number was one fitting in 105-B. Three fittings have been removed for study and the "O" rings in these fittings were in excellent condition. A program is now being started to remove approximately ten of the assemblies with longest reactor life from each reactor to evaluate their present conditions so that their total reactor life may be better estimated. The operating history of the "O" ring seal in these assemblies to date is good.

However, some external pitting corrosion has already started on the pigtails. The cause of this corrosion must be determined to prevent future failures in these pigtails similar to that occurring in the present spiral pigtails.

In 105-H, however, the story is different. Of approximately 1500 assemblies installed in January 1959 approximately 200 have been removed as leakers. The "O" rings in these leakers show evidence of hard physical abuse and in a number of instances appear to have been rolled and twisted in place. The metal on the pigtails in some instances is actually worn as is the metal on the adapter. All the pigtail wear takes place on the outside of the bend indicating the pigtail tries to straighten out in service. The failure of these fittings is probably attributable to the following:

1) Continuous combined vibration and oscillations of sufficient amplitude to roll the "O" ring and wear the metal surface.

2) The "boiler scale" which is externally deposited on the pigtail and can be pulled into the "O" ring seal as different operating positions are taken with each reactor operating period.

3) Freezing of the "O" ring at one operating point and subsequent rolling of this ring as the pigtail moves to shutdown position or to a new operating position.

4) Depolymerization of the "O" ring due to the use of silicone lubricant at initial installation.

It is the writer's opinion that it is the continuous vibrations and oscillations that is causing the majority of the damage. It is felt that the appearance of the failed parts and the fact that this is the only item of the four listed which is much different in 105-H than the other reactor bears out this contention. Vibration studies will be conducted by Plant Engineering to determine these vibration characteristics.

Two modifications will be tried to alleviate the "H" problem and still salvage the present fittings:

1) Install "O" rings of a nitrile rubber (By Car 1002) with a tensile strength of 3200 psig. (vs. 800 psig for silicone rubber).

2) Install "quad rings" which are specifically designed to prevent rolling.

The 105-H problems should be studied closely as these problems probably represent the accelerated on-pile development test of what will ultimately happen at the B, D, DR, and F Reactors.

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One other problem has been experienced with the J-1 type of pigtail assembly, i.e., because of the sharp contact surface when it joins the crossheader Parker fitting it can squeeze down on this Parker fitting and thereby cause reduction of process tube flow. This can be corrected by increasing the area of contact surface and by limiting torque at assembly.

J-2 Slip Joint Assemblies

As shown in Table #2 approximately 30% of these fittings have been installed to date and only one month's operating experience has been obtained.

Some of the problems encountered to date with these fittings are as follows:

1) Stress Concentration--The cast "Y" adapter has a point of stress concentration where the adapter nut is attached to the casting. When this fitting was vibrated with a total deflection amplitude of .050" at its natural frequency the fitting failed after approximately 15,000 cycles. What this means in terms of reactor life will depend upon the amplitude and frequency of vibrations present upon the reactor. On-pile measurements of these items have been arranged for at 105-B, D or F Reactors. Any future design of this assembly should be modified to alleviate this point of stress concentration.

2) Installation Problems--Installation of the "Y" adapter is more difficult than is installation of the straight bar stock adapter. This is especially true in 105-DR where the adapter nut is directly under the gunbarrel flange. A special aligning and nut driving tool should be developed to aid in installing these fittings. In a few instances both the J-1 and J-2 pigtails interfere with the nozzle sufficiently to cause misalignment at the "O" ring junction point. There is no fixed distance between crossheader and nozzle Parker fittings and even if fittings were perfectly aligned during shutdown they probably become misaligned during operation. Any fittings installed must be capable of adjusting to these dimensional variances. This problem will magnify as larger, less flexible, pigtails are installed.

3) Adapter Fitting Metalurgy--The two specimens which broke in vibration testing gave indication that there may be some slag inclusions present. Because of this no further assemblies should be installed until they have been passed by appropriate inspection. If reactor operating experience shows the bronze alloy to be satisfactory, the specification should be charged from ASTM B-143-52 to ASTM B-61-52 for better control during casting.

Future Development

Future development effort on pigtails systems should not be concentrated entirely on a slip joint design. If long lived process tubes ever become a reality any "O" ring on packing gland type of seal will then become the weakest link in the process-tube-piping chain. This is particularly true if continuous operation is also a reality.

Preliminary development work has started on a metallic bellows expansion joint in a "J" configuration of pigtail and braided stainless steel hose type of pigtail.

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J. W. Hedges, Engineer
Mechanical Development "A"
FACILITIES ENGINEERING

JWH:on

04/20/1994
### Table 1: Cost Comparison of Different Pigtailing Assemblies Under Different Replacement Programs

<table>
<thead>
<tr>
<th>Conditions Existing At Time of Replacement</th>
<th>Replacement With Existing 20K Type Pigtails</th>
<th>Replacement with Beveled J-3 (bevel stock adapter &quot;O&quot; ring on pigtails) Assemblies</th>
<th>Replacement with J-2 Assemblies (cost bronze &quot;$1&quot; adapter)</th>
<th>Replacement with Metallic Seal Type Assemblies (bolts or brazed pigtails)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crash program; no overboring of existing Parker fitting; continued use of replacement program; 3 yrs. installed period; &quot;O&quot; rings replaced as tubes are replaced; average &quot;O&quot; ring life 5 yrs. before replacement.</td>
<td>1500 $11 ea = $16,500</td>
<td>1500 $10 ea = $15,000</td>
<td>1500 $18 ea = $27,000</td>
<td>1500 $30 ea = $45,000</td>
</tr>
<tr>
<td>Outage time for initial installation—includes thermocouple relocation with J-2</td>
<td>16 shifts @ $15,000/shift = $240,000</td>
<td>12 shifts @ $15,000/shift = $180,000</td>
<td>16 shifts @ $15,000/shift = $240,000</td>
<td>15 shifts @ $15,000/shift = $225,000</td>
</tr>
<tr>
<td>Tube replacement time increases due to thermocouple work and more difficult pigtails.</td>
<td>500 tubes @ 5 min/tube @ $30/min = $75,000</td>
<td>600 tubes @ 2 min/tube @ $30/min = $36,000</td>
<td>600 tubes @ 3 min/tube @ $30/min = $54,000</td>
<td>600 tubes @ 3 min/tube @ $30/min = $54,000</td>
</tr>
<tr>
<td>Outage time to remove and install fittings for Parker fitting overbore.</td>
<td>16 shifts @ $15,000/shift = $225,000</td>
<td>12 shifts @ $15,000/shift = $180,000</td>
<td>12 shifts @ $15,000/shift = $180,000</td>
<td>13 shifts @ $15,000/shift = $195,000</td>
</tr>
<tr>
<td>Cost of fittings that must be discarded for new design compatible with overboring.</td>
<td>1500 $11 ea = $16,500</td>
<td>1500 $8 ea = $12,000</td>
<td>1500 $18 ea = $27,000</td>
<td>1500 $30 ea = $45,000</td>
</tr>
<tr>
<td>Cost of unscheduled outages due to failures of existing pigtails while replacement fittings are being developed.</td>
<td>no delay</td>
<td>no delay</td>
<td>no delay</td>
<td>9 mos. development time 3 outages @ 6 shifts/outage @ $15,000/shift = $270,000</td>
</tr>
<tr>
<td>Increased outage time to maintain &quot;O&quot; rings on tubes not replaced at end of 3 yrs.</td>
<td>no &quot;O&quot; rings</td>
<td>600 fittings @ $1 min/fitting = $600,000</td>
<td>600 fittings @ $1 min/fitting = $600,000</td>
<td>14 mos. development time 3 outages @ 6 shifts/outage @ $15,000/shift = $210,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$250,000</strong></td>
<td><strong>$250,000</strong></td>
<td><strong>$250,000</strong></td>
<td><strong>$250,000</strong></td>
</tr>
<tr>
<td>Delayed program; allows time (9 mos.) for development of fittings which could be adaptable to reactor improvement program based upon continued tube replacement program—&quot;O&quot; ring life 7 yrs. Parker fitting overbore when pigtails are replaced assumes Parker fitting overbored for evaluation completed in 3 mos.</td>
<td>1500 $11 ea = $16,500</td>
<td>1500 $8 ea = $12,000</td>
<td>1500 $30 ea = $45,000</td>
<td>1500 $30 ea = $45,000</td>
</tr>
<tr>
<td>Outage time for initial installation—includes thermocouple relocation with J-2</td>
<td>12 shifts @ $15,000/shift = $180,000</td>
<td>600 tubes @ 2 min/tube @ $30/min = $36,000</td>
<td>600 tubes @ 3 min/tube @ $30/min = $54,000</td>
<td>600 tubes @ 3 min/tube @ $30/min = $54,000</td>
</tr>
<tr>
<td>Tube replacement time increases due to thermocouple work and/or threaded pigtails</td>
<td>no delay</td>
<td>no delay</td>
<td>no delay</td>
<td>9 mos. development time 3 outages @ 8 shifts/outage @ $15,000/shift = $270,000</td>
</tr>
<tr>
<td>Cost of unscheduled outages due to failure of existing pigtails.</td>
<td>no &quot;O&quot; rings</td>
<td>600 fittings @ $1 min/fitting = $600,000</td>
<td>600 fittings @ $1 min/fitting = $600,000</td>
<td>12 mos. development time 3 outages @ 8 shifts/outage @ $15,000/shift = $360,000</td>
</tr>
<tr>
<td>Increased outage time to maintain &quot;O&quot; rings on tubes not replaced at end of 3 yrs.</td>
<td>no &quot;O&quot; rings</td>
<td>no &quot;O&quot; rings</td>
<td>no &quot;O&quot; rings</td>
<td>no &quot;O&quot; rings</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$365,000</strong></td>
<td><strong>$365,000</strong></td>
<td><strong>$365,000</strong></td>
<td><strong>$365,000</strong></td>
</tr>
<tr>
<td>Long-term program; tubes replaced with 10-yr. life tubes; &quot;O&quot; ring life assumed at 3 yrs.; metallic seal rated at 10 yrs. assumed long lived tubes are available in 3 yrs.; &quot;O&quot; ring life assumed to be 3 yrs.; assumes nozzles must be removed for future expansion program. Assumes that pigtailing corrosion problem has been solved by this time—extra access hole needed for sample point or pressure tap.</td>
<td>1500 $11 ea = $16,500</td>
<td>1500 $10 ea = $15,000</td>
<td>1500 $18 ea = $27,000</td>
<td>1500 $30 ea = $45,000</td>
</tr>
<tr>
<td>Outage time for initial installation—includes thermocouple relocation with J-2</td>
<td>12 shifts @ $15,000/shift = $180,000</td>
<td>6 shifts @ $15,000/shift = $90,000</td>
<td>10 shifts @ $15,000/shift = $150,000</td>
<td>11 shifts @ $15,000/shift = $165,000</td>
</tr>
<tr>
<td>Cost of &quot;O&quot; ring replacements during 10-yr. operating period—subscale replacement program</td>
<td>no &quot;O&quot; ring</td>
<td>1500 tubes @ 3 replacements @ $30/min = $45,000</td>
<td>1500 tubes @ 3 replacements @ $30/min = $45,000</td>
<td>10 shifts @ $15,000/shift = $150,000</td>
</tr>
<tr>
<td>Cost of providing access holes at later outages</td>
<td>16 shifts @ $15,000/shift + $20,000/material @ $250,000</td>
<td>12 shifts @ $15,000/shift + $20,000/material @ $250,000</td>
<td>12 shifts @ $15,000/shift + $20,000/material @ $250,000</td>
<td>None required</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$396,500</strong></td>
<td><strong>$396,500</strong></td>
<td><strong>$396,500</strong></td>
<td><strong>$396,500</strong></td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Reactor: J-1 (Bar Stock Adapter) Pigtail Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Number Installed</strong></td>
</tr>
<tr>
<td><strong>2. Approximate Installation date</strong></td>
</tr>
<tr>
<td><strong>3. Known &quot;O&quot; Ring Failures</strong></td>
</tr>
<tr>
<td><strong>4. Pigtail metal Failure</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reactor: J-2 (Cast Bronze &quot;V&quot; Adapter) Pigtail Assemblies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Number Installed</strong></td>
</tr>
<tr>
<td><strong>2. Date Installed</strong></td>
</tr>
<tr>
<td><strong>3. Failures</strong></td>
</tr>
</tbody>
</table>

**TABLE II**

**"X" TYPE PIGTAIL INSTALLATION HISTORY**

<table>
<thead>
<tr>
<th>Reactor</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>DR</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-1</td>
<td>100 (Approx.)</td>
<td>200 (Approx.)</td>
<td>260-270</td>
<td>350 (Approx.)</td>
<td>1500</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Number Installed</td>
<td>100</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Approximate Installation date</td>
<td>10/4/58 Remainder concurrent with tube replacement</td>
<td>Date Fall 1958</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Known &quot;O&quot; Ring Failures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>none</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Pigtail metal Failure</td>
<td>none</td>
<td>none</td>
<td></td>
<td></td>
<td>none</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

J-2 (Cast Bronze "V" Adapter) Pigtail Assemblies

<table>
<thead>
<tr>
<th>Reactor</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>DR</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-2</td>
<td>none</td>
<td>16</td>
<td>none</td>
<td>none</td>
<td>10-15</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Number Installed</td>
<td>none</td>
<td>16</td>
<td>none</td>
<td>none</td>
<td>10-15</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Date Installed</td>
<td>none</td>
<td>August 1959</td>
<td>none</td>
<td>none</td>
<td>August 1959</td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Failures</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Approximately 200—Leakers occurring at rate of 30/month.**

**Two—cause unknown.**