Transient Rod Drop Time

A Synopsis of a Reportable Event

Mac E. Bryan
Radiation Science and Engineering Center
The Pennsylvania State University
University Park, PA 16802
mebnuc@engr.psu.edu
Brief Description

• Transient rod is a pneumatically coupled control rod. Used primarily for steady-state operations and reactor pulsing.
Transient Rod

Figure 4.17 The Transient Rod Drive

* Replaced by a servo motor that rotates the ball-nut assembly by means of a timing belt.
Simplified Drawing
What happened?

- During a Nuclear Engineering laboratory, Reactor Operations and Testing, the Tr rod appeared to be slow falling into the core after a pulse trip as observed on DCC-X by the operator.
DCC-X Control Computer

[Image of a control panel with various readouts and settings]
Tech. Spec. Requirement

• The time from SCRAM initiation to the full insertion of any control rod from a full up position shall be less than 1 second.
Immediate Actions

• Reactor Immediately Secured
• Duty SRO Notified
• Associate Dir. of Operations Notified
• System Expert Notified
• AP-4 Event Evaluation Initiated
The Investigation

• Message log reviewed.
<table>
<thead>
<tr>
<th>Time</th>
<th>Message</th>
<th>Event Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:39:30</td>
<td>T Pulse in Progress</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:30</td>
<td>T N-16 Pump requested</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:32</td>
<td>T Pulse Timer SCRAMed</td>
<td>(RSS) DI</td>
</tr>
<tr>
<td>14:39:32</td>
<td>T Reg Rod SCRAMed</td>
<td>(RSS) DI</td>
</tr>
<tr>
<td>14:39:32</td>
<td>T Shim Rod SCRAMed</td>
<td>(RSS) DI</td>
</tr>
<tr>
<td>14:39:32</td>
<td>T Safety Rod SCRAMed</td>
<td>(RSS) DI</td>
</tr>
<tr>
<td>14:39:32</td>
<td>T Transient Rod SCRAMed</td>
<td>(RSS) DI</td>
</tr>
<tr>
<td>14:39:32</td>
<td>T Manual Mode entered</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:32</td>
<td>F Apply Air to Transient Rod</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:32</td>
<td>F Pulse in Progress</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:33</td>
<td>T FC Power High X-SCRAM</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:33</td>
<td>T GIC Power High X-SCRAM</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:33</td>
<td>T X-SCRAM Requested</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:33</td>
<td>T Reg Rod Bottomed</td>
<td>DI</td>
</tr>
<tr>
<td>14:39:33</td>
<td>T Shim Rod Bottomed</td>
<td>DI</td>
</tr>
<tr>
<td>14:39:33</td>
<td>T Safety Rod Bottomed</td>
<td>DI</td>
</tr>
<tr>
<td>14:39:35</td>
<td>T N-16 Pump requested</td>
<td>DO</td>
</tr>
<tr>
<td>14:39:36</td>
<td>T Pulse Timer tripped X-SCRAM</td>
<td>DI</td>
</tr>
<tr>
<td>14:39:36</td>
<td>T Transient Rod Bottomed</td>
<td>DI</td>
</tr>
</tbody>
</table>
Message Log Indications

- Tr rod drop times appear to be correct on first pulse of the day (Pulse 7388 Typically 1-2 seconds)
- Pulse 7389 2 seconds.
- Pulse 7390 3 seconds.
- Pulse 7391 Tr rod drop time messages indicate 4 seconds.
Investigation Continues

- AP-10 DNO Placed on the Console
- Tr rod drop time measured (1.47 secs.) prior to any maintenance performance.
- Reportable Event due to drop time.
- CCP-9 (Checks and Calibration Procedure) Tr Rod Cleaning and Lubrication Completed
- Subsequent drop time was 0.760 ms.
Follow-up

• Tr rod drop measured 790 ms. 1 week later.
• Since multiple pulses are to be performed, A CCP-9 Tr rod lubrication is performed.
• As left Tr rod drop time 860 ms.
• Tr rod completely disassembled and inspected.
Cylinder End Cap with Damaged Kapseal
O-ring and Damaged Kapseal
Damaged Kapseal
Swollen O-rings Removed

Swollen O-Ring Removed

New 1" O-R
O-rings Subjected to Lubricant
TR Piston Rod Drag vs Gland Diam

\[ y = 16123x^2 - 15154x + 3563.1 \]

\[ R^2 = 0.9823 \]

Drag (oz)

Gland Diam (inches)
Root Cause

• The damaged teflon Kapseal allowed the o-ring to contact the piston rod drastically increasing the friction.

• The seal was damaged by increased pressure exerted against the rod by the swollen o-ring.
Now What?

• Initially we implemented daily rod drop measurements, which, based on the data has been increased to weekly and now monthly.
• The CCP-9 Transient Rod Inspection has been modified to inspect and/or replace the Kapseal and o-ring annually.
• Lubricant is specifically identified.