



The Evolution of Pump Inservice Testing

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Disclaimer

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The Origins of O&M

- The Committee on Operation and Maintenance of Nuclear Power Plants (O&M Committee) formed June 1975 (ANSI N45 “Committee on Reactor Plants and Their Maintenance” – disbanded)
- Section XI subgroup on Pumps and Valves was transferred to the O&M Committee in 1979 as the O&M Working Group on Pumps and Valves
- Original Intent: OM Parts to be referenced in IWP and IWV of ASME B&PV Code Section XI (parallel committees – cumbersome)

The Origins of O&M

- Subsections IWP and IWV were to be moved to a new code, Operations and Maintenance of Nuclear Power Plants.
- ASME B&PV Code Section IWP and IWV become OM Part 6 and Part 10.
- Part 6 and 10 become OM ISTA, ISTB, and ISTC. OM Part 1 and Part 13, Safety and Relief Valves, and Power Operated Relief Valves, became OM Appendix 1

OM Purpose/Intent

- Detect deviations from a condition that was previously determined to be acceptable. (cause of the deviation and correct)
- Trend IST to detect declined performance – prepare to correct it before it breaks

A Component Code

- The OM Code IST - operational readiness (not operability).
- Not a system code nor does it have "explicitly stated objectives". What was to be included or excluded?

OM 6 from IWP

- Scope no longer limited to ASME Class 1, 2, or 3.
- Measurement of pump bearing temperature removed.
- Trending of vibration, was thought to be better indicator for pump degradation versus hydraulic performance
- Pump testing on minimum flow recirculation was permitted
- Pump Verification Flow Test was outside the original scope of O&M.

The Dawn of Comprehensive Pump Testing

- Testing at very low flow is meaningless for tending degradation.
- Plants with test loops with substantial flow capability, had no issue.
- Plants that tested on minimum flow had an issue.
- The solution; Comprehensive Pump Test (CPT)
- Pump Categories; what was the intent?

Pump Categories; the Intent

- Pump Categories allowed pumps that were not used continuously to be tested only when larger flows were possible.
- Categories defined Normal versus Standby
- Some plants shift category A to B and visa versa
 - Not the intent (more on that latter)

Comprehensive Pump Testing

- Oil analysis was removed.
- Motor current measurement was removed. The stated reason was that motors are outside the scope of O&M.
- Complicated the situation for BWRs because the quarterly and comprehensive tests had different acceptable bands, you could not add the comprehensive test result into the trend with the other tests.

The Richardson Letter

- In Service Testing was not predicting pump and valve failure. (Generic Letter 89-10).
- IST fundamentally changed by the Richardson Letter.
- IST should not be limited to ASME Section III Components
- Minimum flow lines flowrate instruments
- Verification should be at design basis conditions, or when not possible by test, verified by analysis.

Three Open Issues preventing NRC Endorsement

- Test flow rate needed to include maximum credited flow rate
- High end acceptance criteria tolerance for flow
- Group B tests.

Code Resolutions

- OM Code - component code. Verification flow test was not the intent of the code. Compromise the flow verification test.
- Percent of flow on the high end that would put a pump in the required action range. Complication here is that acceptance criteria, as well as instrument accuracy differ for quarterly vs. comprehensive test.
- Group B test is to ensure that the pump can start and come up to its reference point.

Learning from the past

- Comprehensive Pump Test (original intent)
 - Oil analysis (maintenance not testing?)
 - Motor current measurement was removed (motors are outside the scope)
- Introducing Pump Condition Monitoring (PCM)

WHAT DOES PUMP CONDITION MONITORING (PCM) LOOK LIKE?

First Steps

Assess the design, test history, and maintenance history (include the electrical system of the pump)

Determine;

- additional PCM technologies
- acceptance criteria
- equipment to be included in the PCM program

In addition to Code hydraulic test PCM includes;

- enhanced vibration analysis
- lube oil analysis
- thermography
- motor current signature analysis
- motor electrical parameters
- process and equipment parameters

PCM Technologies

- Vibration Analysis:
 - State-of-the-art equipment for collecting and analyzing spectral vibration data to monitor (A primary technology of PCM along with lube oil analysis)
- Lube Oil Analysis:
 - Analyze oil properties (base oil as well as additives) to identify presence of contaminants & debris.
- Thermography:
 - Detect & measure variations in the heat and transforming into visible signals that can be recorded.

PCM Technologies (cont'd)

- Motor Current Signature Analysis:
 - Motor current signature analysis involves analyzing motor current data in the frequency domain.
- Process and Equipment Parameters:
 - Process and equipment parameter variations may impact condition monitoring results. Applicable process and equipment data should be collected in conjunction with the equipment condition monitoring data.
- Equipment Walk Downs
 - When doing walk downs of the equipment or during operator rounds and data collection, visual, auditory, olfactory, and tactile observations of equipment sounds, smells, discoloration, casing and bearing housing temperature changes or leaks can identify potential equipment problems that left unattended could lead to equipment failure.

THE CASE FOR A CONDITION MONITORING OF PUMPS

Comprehensive Pump Testing – the original intent

More than just the pump

- Use the pump driver to monitor pump health (currently done for motor actuated valves). Draft CPT requirements included taking motor current
- Use vibration equipment that would provide state-of-the-art vibration testing. Draft CPT used of state-of-the-art vibration testing.
- Include sampling of oil as a tool of IST (part of the original ASME Section XI)

OM versus OM-2

- OM (generally) plants already built
 - Quite a bit of latitude to avoid requiring a plant to make any physical changes.
 - IWP and IWV, as well as OM Parts 6 and 10 for the most part used deterministic techniques that used very clear, go/no go acceptance criteria.
 - Testing interval (time between tests) on the ability to do the test based on plant operation.
 - Little regard for duty cycle of the component. Higher cycle – More Frequent testing?

OM-2 Pump Tests

- O&M is pursuing new criteria for valves where testing interval may be more condition based, rather than simply by calendar time or plant fuel cycle.
- Pumps did not typically have test loops that permitted substantial flow. New build plants shall have them - better testing with more data points to trend.
- O&M scope does not include pump motor testing, we resist using the pump motor to verify the health of the pump. Other industries specifically do exactly that

OM-1

- The committee is currently undertaking a reformat of OM. It will be designated OM-1. No more pump categories?
- Group A versus Group B
 - Over a two-year interval six tests with one acceptance criteria and two with another (you need three to establish a trend)
- Pump Categories-Intent
 - Pumps that can be tested irrespective of facility operation versus pumps that cannot

Questions ??