PIPE SUPPORT PROGRAM at PICKERING

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ABSTRACT

This paper describes the Pipe Support Program at Pickering. The program addresses the highest priority in operating nuclear generating stations, safety. We present the need: **safety,** the process: **managed and strategic,** and the result: **assurance of critical piping integrity.** In the past, surveillance programs periodically inspected some systems, equipment, and individual components. This comprehensive program is based on a managed process that assesses risk to identify critical piping systems and supports and to develop a strategy for surveillance and maintenance. The strategy addresses all critical piping supports. Successful implementation of the program has provided assurance of critical piping and support integrity and has contributed to decreasing probability of pipe failure, reducing risk to worker and public safety, improving configuration management, and reducing probability of production losses.

Introduction

Before getting into a discussion of the Pickering Pipe Support Program, let's begin with an analogous comparison of the foundation of a building with the supports (and hangers) of a piping system. If the building's foundation is not properly designed, constructed, or is deteriorating from age, the integrity of the entire building is in danger. Similarly, supports are the foundation of piping systems, and if the supports are not properly designed, installed, and maintained, the entire piping system is at risk of failure. The resulting consequences of failure are injuries to workers and public, and unit shut down.

The above conclusions are valid for all piping systems in all industries including petro-chemical, thermal generating stations, and especially in nuclear generating stations where worker and public safety are of paramount importance. Today there are hundreds of nuclear units in service producing power, and they are aging. Given the extent of piping in nuclear stations, and that safety is the primary concern, the piping systems must be maintained in good condition. To achieve this, a managed process must be in place to ensure that the supports and hangers of piping systems are in good condition and are performing well.

Section XI of the ASME Boiler and Pressure Vessel Code specifies rules for maintaining the plant in good operating condition, and for returning the plant to service in a safe and expeditious way following an outage. The rules include requirements for inservice inspection of nuclear power plant components that specify a mandatory program for examination, testing, and inspection to prove adequate plant safety. The code assigns to the plant owner the responsibility for developing a program that meets the requirements of section XI of the code.

The Canadian standard CSA-N285.4 specifies similar requirements. Both the ASME Code and the CSA Standard include piping systems and their supports among components that require periodic inspection programs. In the past, there have been inspection programs for some components such as valves, or individual supports, on some systems, but a program was never implemented at Pickering that would address the risk of all supports on all critical nuclear and conventional systems. Following several incidents of piping failure attributable (at least in part) to pipe supports, the Pickering Pipe Support Program was initiated in 1992-3.

Program Objective

The purpose of the pipe support program is to mitigate the impact of piping system deficiencies on station performance. Plant experience shows that support deficiencies (degradation) are a precursor to support and piping failure. Therefore, the objective is achieved by reducing the frequency of pipe support deficiencies, which reduces the probability of piping failure. The impact of piping failure to station performance is summarized as follows:

- worker safety (conventional safety concerns)
- public safety (nuclear safety concerns)

Methodology

The basis for achieving the program's objective is by implementing a managed process that includes the following generic elements of component programs:

- Identifying critical piping systems based on risk to station performance. (Scope and Risk Assessment).
- Developing a strategy for critical piping system supports. (Strategy Development).
- Revising the strategy as new information is obtained. (Strategy Maintenance).
- Developing documentation to permanently record the program and process, including inspection and maintenance history database, and design configuration maintenance. (Documentation).

The basic elements of the process are further described below.

Scope

To optimize the program effectiveness, it is necessary to limit the strategy to supports in critical piping systems. Those systems and supports have the highest consequences of failure and pose the highest risk to station performance. All nuclear and conventional piping systems were evaluated. The following criteria was applied to determine critical piping systems and supports that are included in the strategy:

1. **Worker Safety:** Piping failure can cause fatality or permanent disability. (Energy Related Consequence).
2. **Public Safety:** Piping failure can cause Type "A" process failure or safety system unavailability. (Nuclear Safety Related Consequence).

Criteria with production or environmental impact were not applied. Those criteria affect only economics. Since the absolute probability of piping failure attributable to supports is very low, systems with only economic consequences do not justify the cost of being including in the strategy. The piping system evaluation yielded the following results:

- Nuclear Piping Systems: 22 of 73 are included in the strategy.
- Conventional Piping Systems: 57 of 118 are included in the strategy.
- Total: 79 of 191 piping systems are included in the strategy.

Risk Assessment

Risk is the product of the consequence and probability of failure. The risk associated with the failure of piping was qualitatively evaluated for all piping systems, and was classified as high, medium or low. Piping systems with low risk are not included in the strategy. Consequence and probability were independently evaluated, and were defined as follows for the pipe support program:

Consequence of Failure

- The consequences of failure impact **Worker Safety** (Energy related consequences) or **Public Safety** (Nuclear safety related consequences).
- Energy is determined by type of fluid, pressure, temperature, and pipe size.
- Nuclear safety relatedness is determined by nuclear safety classification (function).

Probability of Failure

- The probability of pipe failure is determined from the rate and severity of degradation occurrences observed during previous inspections.
- The probability is evaluated relative to the other piping systems in the strategy. However, even a high relative probability piping system will typically have low likelihood of pipe failure.

Strategy Development

The long term strategy is specified for all critical piping system supports. The strategy includes the required inspection periods of pipe supports for the remaining life of the station on the basis of the assessed risk. The assessments and strategy are unique for each system and address system specific characteristics such as known degradation mechanisms, proximity to plant personnel and sensitive or safety related equipment, system duty cycle, and piping configuration.

For piping systems included in the strategy (critical piping), the inspections include all supports in each system. Systems excluded from the strategy (non-critical piping) are periodically inspected during the SRE's system walk down inspections according to the needs determined by the SRE.

The initial inspections begin with high risk systems and are conducted during the nearest planned outage, and then progress to medium risk systems. All initial inspections will be completed by 2001. Inspections cycles begin with the units longest in service to reveal the most advanced effects of the degradation mechanisms. The normal periods for subsequent inspections are 2 to 4 years for high risk systems and 4 to 8 years on medium risk systems, depending on initial inspection results.

The current inspection schedule completes about 3000 support inspections per year for 8 units. The schedule will peak to about 4500 inspections per year during 1998 to 2002. That rate of inspection is expected to significantly reduce in the future for several reasons:

- The current volume of inspections is high in order to complete the initial inspections as quickly as practical. Repeat inspections are based on inspection results.
- The program was initiated after many years of accumulating service degradation.
- Initial inspections include all supports on each system. Subsequent inspections will focus on supports that are more susceptible to degradation (based on inspection results).

Strategy Maintenance

The program strategy is revised periodically to improve overall effectiveness. The revisions may result from:

- Inspection results: Results provide feedback on program effectiveness and reveal degradation trends.
- Events: Unforeseen events may impact equipment condition and can change the assessed risk and priority of systems. Events include internal and external operating experience.
- Operating Practices: Changes to system operating parameters or frequency can alter degradation trends.
- Outage Schedule: Changes to outage schedule may require revisions to inspection frequency.

Documentation

A database was developed and is maintained to record inspection results and repair status. The database is used for reporting, program administration, and provides a source for obtaining historic information and trending. In addition to electronic data storage, paper records are kept of all inspection campaigns and results. For each support inspected, the following information is filed permanently:

- Photographs of each support to illustrate support condition and deficiencies.
- Copy of inspector's field data sheets.
- Marked up piping general arrangement drawing.
- Pipe support drawing or design specification.
- Program engineer's deficiency report (Includes WMS DR).
- DR completion record (Campaign Monitoring Report).

The program's strategy and processes are described and documented as follows:

- Pickering Division Component Strategy (P-DCS) - Contains the program scope, risk assessment and strategy.
- Component Surveillance and Maintenance Program (CSMP) - Contains annually revised schedule and resource estimates for executing the strategy.
- Pipe Support Inspection and Repair Procedure - Defines the roles and responsibilities of individuals and work groups for the inspection, repair, and documentation of pipe supports.

Inspection and Repair Process

The pipe support inspection and repair process includes the following key steps:

1. Scope Identification: Prior to commencing an inspection and repair campaign, the Program Responsible Engineer (PRE) reviews the proposed scope (as determined by program strategy and schedule) with the System Responsible Engineer (SRE) and Design Responsible Engineer (DRE). The scope is agreed upon and communicated to production.
2. Inspection: The PRE establishes an inspection contract with QC/NTS. Qualified inspectors conduct visual examinations of the pipe supports in accordance with an approved inspection procedure. The inspectors record all observations on field data sheets, drawings and photograph each support.

3. Results Reporting: The inspectors submit all recorded results to the PRE for documentation, review, and processing. The PRE initiates action DRs to the SRE for all supports with deficiencies, and issues a deficiency summary report to the SRE and DRE. At the end of the campaign the PRE files all disposition reports, and documents DR completion.
4. Dispositions: The DRE assesses and dispositions all non-conformances before the unit returns to service. Dispositioning consists of recommending repairs for unacceptable non-conformances, or accepting the field configuration and updating drawings and specifications to reflect the as built condition.
5. Repairs: The SRE assess and executes repair of all supports with degradation and non-conforming supports that require repairs before the unit returns to service.

Inspection Results

The purpose of pipe support inspections is to reveal deficiencies. The following types of deficiencies were observed in the field:

Non-Conformances

- Incorrect Initial Design: Inspections revealed non-conformance such as insufficient number of supports, pipe vibration or movement not analysed properly, specified support type not suitable for application, etc.
- Incorrect Installation: Observations included supports in wrong location, missing supports, incorrect welds, wrong configuration.

Degradation

- Observed support deterioration caused by known degradation mechanisms included loosened components, missing nuts and bolts, broken or bent components, excessive clearances, corrosion, fretting etc.

In addition to individual deficiencies, the inspection revealed the following general findings:

- Some systems were in very good condition with minimal degradation and few non-conformances, but in general, far more degradation was observed than expected.
- The condition of most systems was consistent from unit to unit, with few exceptions.
- Systems with field run piping and supports were in worse condition than systems with engineered supports.

The results of two recent inspections campaigns are shown in Tables 1 and 2. The tables list the systems inspected, the number of supports, deficiencies observed, and repairs completed. The Unit 6 and Unit 8 planned outage campaigns were selected because those were the first two large scope campaigns completed under the requirements of the Pickering Pipe Support Program. The inspections and repairs were completed, reported, and documented to a higher standard than ever before, which achieved the most accurate results.

Table 1: Pipe Support Inspection - Unit 6

Nuclear Systems

No. of systems inspected:	11
No. of supports inspected:	542
No. of supports not accessible:	18
No. of deficiencies:	54
No. of repairs required:	25

System	No. of Supports in System	No. of Supports Inspected	Deficiencies	Repairs Required
32100 - Moderator Main Circuit	24	23	0	0
32200 - Moderator Purif. Circuit	26	26	0	0
33110 - Boiler Isol Valve Sppts	24	24	0	0
33110 - Boiler Spring Hangers	108	108	0	0
33120 - PHT Main Circuit	96	90	5	1
33210 - PHT Purif. Circuit	47	36	2	0
33310 - PHT Feed Circuit	22	22	6	2
33312 - PHT Pump Supports	48	48	5	4
33320 - PHT Bleed Circuit	73	73	17	12
33350 - ECI Hangers	41	41	0	0
33610 - PHT Relief Circuit	51	51	19	6
TOTAL	560	542	54	25

Conventional Systems

No. of systems inspected:	6
No. of supports inspected:	547
No. of supports not accessible:	0
No. of deficiencies:	165
No. of repairs required:	55

System	No. of Supports in System	No. of Supports Inspected	Deficiencies	Repairs Required
71340 - HPSW	242	242	53	9
71310 - LPSW	100	100	71	25
43230 - Boiler Feed	32	32	16	10
36410 - Boiler Blowdown	59	59	5	2
36110 - Main Steam	16	16	4	4
71320 - Recirc. Cooling Water	98	98	16	5
TOTAL	547	547	165	55

Table 2: Pipe Support Inspection - Unit 8				
Nuclear Systems				
No. of systems inspected:	4			
No. of supports inspected:	190			
No. of deficiencies:	51			
No. of repairs required:	29			
System	No. of Supports in System	No. of Supports Inspected	Deficiencies	Repairs Required
33310 - PHT Feed Circuit	22	22	12	10
33312 - PHT Pump Supports	48	48	12	4
33320 - PHT Bleed Circuit	73	73	12	8
33610 - PHT Relief Circuit	47	47	15	7
TOTAL	190	190	51	29
Conventional Systems				
No. of systems inspected:	5			
No. of supports inspected:	235			
No. of deficiencies:	72			
No. of repairs required:	32			
System	No. of Supports in System	No. of Supports Inspected	Deficiencies	Repairs Required
33610 - PHT Int RV Piping	21	21	4	4
36410 - Boiler Blowdown	40	40	0	0
41130 - Reheater Drains	31	31	12	
43230 - Boiler Feed System	32	32	0	0
71320 - Recirc. Cooling Water	111	111	56	28
TOTAL	235	235	72	32

Table 3 below summarizes the deficiencies and repairs reported in Tables 1 and 2. The values are in percentage of all supports inspected in the respective category. You will note that the percentage of deficiencies and repairs on unit 8 are higher than unit 6. That occurred because systems with higher rates of deficiency were selected for the unit 8 campaign based on the unit 6 results.

Table 3: Deficiency and Repair Summary		
System Class	Unit 6	Unit 8
Nuclear	Deficiency 10% Repair 5%	Deficiency 27% Repair 15%
Conventional	Deficiency 30% Repair 10%	Deficiency 31% Repair 16%

Conclusions

The large number of deficiencies discovered, and repairs completed to correct the deficiencies, prove the program's importance. The greatest benefit achieved by the program is assurance of critical piping and support integrity. In addition, we conclude that the resources and efforts invested in the pipe support program contribute to:

- Decreasing probability of piping failure, thereby, reducing risk to worker safety and public safety.
- Improving the configuration management of the plant by bringing documentation closer to the physical plant configuration.
- Reducing future outage duration and decreasing radiation dose to personnel.
- Reducing the rate of forced and unplanned shut downs between scheduled outages.

We recognize that the efficiency and effectiveness of the program are difficult to measure, but we are confident that program will prevent pipe supports from attributing to the failure of all critical piping in the future. That achievement, and the benefits listed above, have significant value, and justify the program. Furthermore, the efficient manner in which the program is administered adds to the justification. The program's managed process and results obtained are steps towards achieving nuclear excellence at Pickering.

We recommend to other stations to consider the importance of piping system supports, and to implement a similar program to ensure critical piping integrity.