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# Guideline for Compliance to B31.1 Chapter VII, Operation and Maintenance

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# PRODUCT DESCRIPTION

This report provides information and direction to Electric Power Research Institute (EPRI) members on the intent and use of the recently added Chapter VII, "Operation and Maintenance," to American Society of Mechanical Engineers (ASME) B31.1, Power Piping. Traditionally, ASME Codes have been primarily targeted at new construction. The addition of Chapter VII represents a departure from this approach, and it prompts a need for utilities to consider how they will properly address the recently added requirements.

## Results and Findings

The report presents a background of the intent of the ASME B31.1 Chapter VII and the reasons that it was deemed necessary. This background provides users with better insight into how they can meet the requirements of Chapter VII. Also included is information on when these requirements must be applied.

## Challenges and Objectives

This report is important reading for the project managers of new construction projects, who must identify new construction records. Further, the engineering staff of the operating companies to which the Chapter VII requirements apply must be aware of the new requirements.

## Applications, Value, and Use

The potential for future changes in the requirements contained in ASME B31.1, Chapter VII is addressed within this report. Also covered is the possibility of changes in the guidelines for operation and maintenance in Appendix V.

## EPRI Perspective

Recognizing a definite lack of background information available outside of the B31.1 Section Committee on the intent of the changes, EPRI has initiated this project to provide additional information concerning the new requirements of ASME B31.1, Chapter VII. EPRI has a unique ability to offer meaningful insights on the new requirements as a result of its close involvement with the applicable Codes.

## Approach

This report provides the current status of the requirements contained in the recently added Chapter VII of ASME B31.1. The report is classified as a technical update because there is continuing activity within the B31.1 Section Committee that will likely result in additional changes. Forthcoming changes will be addressed in future EPRI reports.


## Keywords

Generation
Maintenance
Operation
Piping
Pressure
Temperature

# ABSTRACT

This report was developed to provide an introduction to new requirements for inspection, documentation, and record-keeping of high-energy piping systems in power plants. In 2007, the American Society of Mechanical Engineers (ASME) issued new guidelines through Chapter VII of ASME B31.1, Power Piping. Chapter VII requires utilities to have a program in place for covered piping systems (CPSs). Systems covered include the main steam, hot reheat steam, cold reheat steam, and boiler feedwater systems. It is intended that these requirements apply only to new piping systems installed in 2007 or later, but utilities can choose to apply them to older systems.

This report is intended to be an introductory guide to Chapter VII. It was originally planned to include sample forms in this report that could be adopted by utilities when developing their CPS program. An ASME working group is now developing documentation forms that will be helpful in this process. Forms were intentionally left out of this interim report but will be developed pending the outcome of the ASME working group.

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# 1
# INTRODUCTION

## 1.1 Background

The 2007 Edition of ASME B31.1, Power Piping, included a significant change that affects owners and operators of power plants. While the B31.1 Code has traditionally been a new construction Code covering the piping primarily located in power generation facilities, an additional chapter was added (Chapter VII) covering new rules for Operation and Maintenance. While this seems to be a significant departure from the former approach, it has been a consideration for many years; since the addition of the "Nonmandatory Appendix V – Recommended Practice for Operation, Maintenance, and Modification of Power Piping Systems". This nonmandatory appendix was added to the B31.1 Power Piping Code in the 1986 Addenda to the 1986 Edition and was a direct response to the catastrophic hot reheat piping failures at the Mohave and the Monroe power plants in 1985 and 1986 (it should be noted that at the time, information on the exact cause of the failures was not generally available to the B31.1 Section Committee).

The B31.1 Committee established a task group to generate Appendix V. The task group was not abandoned after Appendix V was published but was rather redirected to attempt to stay better connected to industry issues such as failures and technical advancements. The task group became known as the Piping System Performance Task Group which then sponsored presentations to the B31.1 Committee on basically any pertinent development. The task group also assumed committee control over the Appendix V. While not a great deal was done in changing Appendix V, it was recognized that there was a need to address the issues of Operation and Maintenance in a more significant way. This became a stronger issue as additional failures accumulated over the years, cumulating in the formation of a higher level Subgroup on Operation and Maintenance within the B31.1 Committee organization. This subgroup was responsible for the development of the Chapter VII on Operation and Maintenance and remains active in further development of the rules within that chapter.

Chapter VII contains mandatory rules that primarily affect owners and operators of power plants containing B31.1 Power Piping since it deals heavily on the programs needed to keep significant systems safe and reliable for the life of the plant. It therefore goes far beyond the concept of only covering new construction. The nonmandatory Appendix V is considered to be a guideline rather than mandatory requirements, providing information that may be used in the mandatory programs but which is not necessarily required by the Code. Many of the mandatory rules were originally contained within the nonmandatory Appendix but were moved to the new Chapter VII since, in the opinion of the B31.1 Committee, some of the rules should not be an option. The Subgroup on Operation and Maintenance continues to meet regularly to consider additional issues that should become mandatory. Therefore the status of Chapter VII is still in development and probably will be for some time (see item 2.3). It was not intended to be a significant burden but was rather viewed as requirements that would likely be already accomplished by responsible utilities. However, it was also realized that having mandatory rules would assist in making sure

that issues important to safety would be addressed and given the necessary regulatory and management support that would be required. It also provided information on plant records that the B31.1 Committee felt was important to maintain in order to effectively establish programs covering operation and maintenance.

There were a number of factors that contributed to the recognition that these rules were needed. In addition to the reports on failures that were now being presented to the B31.1 Committee, the committee realized that plants designed with significantly higher pressures and temperatures were being considered and that materials more sensitive to variations in operation, fabrication and maintenance were likely.

## 1.2 Application

The ASME Codes include a statement (usually in the Introduction to the Code) that states that the intent is that any edition or addenda of the Code will not be retroactive. This means that the requirements of the B31.1 Code regarding the mandatory rules of Chapter VII are not considered to be mandatory for plants where the code of reference was prior to the 2007 edition. The specific paragraph of the Introduction is:

> "It is intended that this Edition of Code Section B31.1 and any subsequent Addenda not be retroactive. Unless agreement is specifically made between contraction parties to use another issue, or the regulatory body having jurisdiction imposes the use of another issue, the latest Edition and Addenda issued at least 6 months prior to the original contract date for the first phase of activity covering a piping system or systems shall be the governing document for all design, materials, fabrication, erection, examination, and testing for the piping until the completion of the work and initial operation."

While this makes the issue clear as far as the Code requirement to follow the rules of Chapter VII, there are regulatory and safety implications to avoiding reasonable practices regarding the operation and maintenance of the most significant of the piping within power generation facilities. Toward this end, the development of the rules contained in B31.1, Chapter VII, are largely based on existing programs within the utilities with representation on the B31.1 Committee. As a result, it is anticipated that many utilities would not have a significant effect on their existing programs.

## 1.3 Piping to Be Included in Program

The primary criterion for mandatory inclusion in the program required by the rules of Chapter VII was a concern for safety. Certainly the energy contained within piping is a major concern, including not only high temperature piping but also piping of moderate temperatures but under high pressures. Size also becomes a consideration from the standpoint of contained energy. In addition, piping was considered where there was industry evidence of a failure history deemed significant by the B31.1 Section Committee.

The piping to be included has been defined as *covered piping systems*. This term is included within the definitions specific to B31.1, contained in Para. 100.2, as follows:

> "*covered piping systems (CPS)*: piping systems on which condition assessments are to be conducted. As a minimum for electric power generation stations, the CPS systems are to include NPS 4 and larger of the main steam, hot reheat steam, cold reheat steam, and boiler feedwater piping systems. In addition to the above, CPS also includes NPS 4 and larger piping in other systems that operate above 750ºF (400ºC) or above 1,025 psi (7100 kPa). The Operation Company may, in its judgment, include other piping systems determined to be hazardous by an engineering evaluation of probability and consequences of failure."

# 2
# PROGRAM REQUIREMENTS

## 2.1 Program Establishment

There are two major requirements for the mandatory program currently listed in B31.1, Chapter VII – procedural control and condition assessment. There are also records requirements that are needed to support the program.

### *2.1.1 Procedural Control*

The first requirement is that procedures are needed in order to adequately control the operation of piping systems and the documentation of the aspects of the operation that could be a factor in assessing their continued safe operation. No specific direction is provided to the Operating Company for these procedures; that is left to the methods established within those organizations. However, the aspects of the operation and maintenance that are required to be addressed within the procedures are listed in Para. 139 of B31.1, Chapter VII. These aspects are repeated as follows:

A. Operation of piping system within design limits

B. Documentation of system operating hours and modes of operation

C. Documentation of actual operating temperatures and pressures

D. Documentation of significant system transients or excursions including thermal hydraulic events (e.g., steam hammers, liquid slugging)

E. Documentation of modifications, repairs, and replacements

F. Documentation of maintenance of pipe supports for piping operating within the creep regime

G. Documentation of maintenance of piping system elements such as vents, drains, relief valves, desuperheaters, and instrumentation necessary the safe operation

H. Assessment of degradation mechanisms, including, but not limited to, creep, fatigue, graphitization, corrosion, erosion, and flow accelerated corrosion (FAC)

I. Quality of flow medium (e.g., dissolved oxygen, pH)

J. Documentation of the condition assessment (see para. 140)

K. Other required maintenance

Review of these procedural aspects reveal that the purpose of these requirements is to provide the basis on which an assessment can be made that the piping is and continues to be in a safe operating condition.

### *2.1.2 Assessment of Condition of Piping System*

The second major requirement is to establish and maintain a program for assessing the actual continuing condition of the CPS for the life of the systems. Specific direction is left to the Operating Company to establish the needed required frequency and scope of the condition assessment. This may be based on factors such as previous assessments, age, operating transients, risk, maintenance, industry experience, examinations, support conditions, etc.; as determined by the Operating Company. Suggested elements of the program are given in Para. 140 of B31.1, Chapter VII, but they are not Code requirements specifically since the need is based on the determination made by the Operating Company. However, it is a B31.1, Chapter VII requirement that a program must be established. In summary, the Operating Company should always know and document the condition of the CPS.

The elements of the program that are suggested to be contained in the program are listed in Para. 140 of B31.1, Chapter VII, but are repeated as follows:

A. System name

B. Listing of original material specifications and their editions

C. Design diameters and wall thicknesses

D. Design temperature and pressure

E. Normal operating temperature and pressure

F. Operating hours, both cumulative (from initial operation) and since last condition assessment

G. Actual modes of operation since last condition assessment (such as the number of hot, warm, and cold starts)

H. Pipe support hot and cold walk-down readings and conditions since last condition assessment for piping systems that are operated within the creep regime

I. Modifications and repairs since last condition assessment

J. Description and list of any dynamic events, including thermal hydraulic events, since the last condition assessment

K. Actual pipe wall thickness and outside diameter measurements taken since the last condition assessment as appropriate based on service

L. Summary of pipe system inspection findings, including list of areas of concern

M. Recommendations for reinspection interval and scope

The condition assessment program is ongoing from the date of initial operation through the operating life of the piping system. However, the Operating Company may determine that the frequency and scope of the condition assessments may need to be varied based on the results of each assessment.

## 2.2 Records

B31.1, Chapter VII, Para. 141 suggests records which should be obtained and maintained as completely as possible. Certainly the procedures and condition assessment documentation required by Paras. 139 and 140 need to be included as they are generated by the Operating Company. These are included as stated in items (A) and (B) of Para. 141.

The original piping drawings, including any as-built drawings, should be gained from the engineering organization or contractor. This may require putting this provision into the contract specification. The piping drawings should also be appropriately updated and maintained should any modification or repair occur on any CPS. These are included as stated in item (C) of Para. 141. Similarly, the support design drawings, including any updates for modified or repaired supports, should also be maintained. These are included as stated in item (D) of Para. 141. Specific design calculations are not mentioned but they should also be requested.

While Chapter VII contains the requirements for records, Appendix V contains significantly more guidance for needed records. Records suggested are detailed within Appendix V. A brief of additional needs is as follows:

- V-1.3.1 – General Requirements: Records and procedures which are likely to be included within program requirements
- V-2.2 – Documentation: Partially required by Chapter VII requirements but also including construction isometrics, flow diagrams, support settings charts, material certification records (should include welding materials), valve data, allowable reactions at piping connections, and welding procedures and records.
- V-5.1 – Records: This list may be partially implied within Chapter VII and in other Appendix V listings but are specifically listed here since the requirements are enhanced by these documents:
    - Procurement documents including specifications
    - Original service date and operating conditions
    - List of materials including system location
    - Physical and mechanical properties including CMTRs, chemical analysis, impact tests, special processing (heat treatments)
    - Wall thickness measurements and design minimum wall
    - Records of alterations
    - NDE reports (including radiographs if applicable)
    - Special coatings or other designs for corrosion or erosion resistance
    - failure reports
- V-5.2 – Failure Reports: Failure reports need to include details of operation and special conditions, cause of failure, corrective actions.

- V-5.4 – Weld Records: Again, the weld records are previously mentioned but further detailed in this item. The weld records should include the welding procedures, procedure and performance qualification records, NDE reports, heat treatment data, and repair records.

## 2.3 Anticipated Future Requirements

As stated previously, the B31.1, Section Committee has continued to consider future changes to Chapter VII. As of this writing, these changes have not been issued as a Code publication. However, the Code is currently considering additional changes which may affect future programs. The emphasis is on the review of nonmandatory Appendix V to determine which rules should be mandatory (therefore moved into Chapter VII) but new requirements are also being considered based on information now available to the B31.1 Committee. It should be noted that this review also results in some clarification and modifications to Appendix V to provide a better guideline toward the maintenance of CPS. As stated in item 1.2, any new Code requirements are not retroactive to existing piping systems contracted to an earlier Code of Reference unless done so voluntarily or due to more restrictive regulatory requirements. Since they are still under consideration, specific information cannot be stated, but the areas under discussion include:

- Walkdowns of CPS
- High temperature creep program

As with the areas of Chapter VII, areas of Appendix V are also under consideration. If changes are made to Appendix V, they may take the form of moving additional requirements into Chapter VII or they may just be further clarifications of the Guideline.

# 3
# GUIDELINE FOR COMPLIANCE TO CHAPTER VII

## 3.1 Initiation of CPS Program

### *3.1.1 Procurement*

Since many of the input records are generated during material procurement and fabrication, the CPS Program requires that these records be specifically included as part of the procurement specifications, insofar as possible. Guidance on what records are needed is provided in Section 2. These records should be associated with the specific CPS to be easily accessible preferably with duplicate copies available. The methods that each Operating Company uses to control these records are left to their controls.

If additional piping systems or subsystems are added to the CPS list at the discretion of the Operating Company (see item 3.1.3), the procurement specifications should indicate the additional material and fabrication records which may be needed.

### *3.1.2 Procedures*

Procedures need to be generated to provide for the control and documentation of the aspects of the CPS Program (for each system as applicable) as listed in item 2.1.1. Again this is left to the Operating Company to meet their internal approaches but the following suggestions are made on each aspect of the required procedures listed in item 2.1.1.

A. Operation of piping system within design limits

Piping system shall not be operated above design limits. This includes temperature, pressure, and flow. Operational procedures as well as instrumentation/calibration standards should be included in the documentation to satisfy this requirement. Procedures should address alarm and trip limits as well as time limits and operational procedures to address each specific alarm.

B. Documentation of system operating hours and modes of operation

The piping system operating hours and the modes of operation such as full load, partial load, standby, and shutdown needs to be documented. The procedures required should define these modes and provide a method of recording the time and number of occurrences in each mode.

C. Documentation of actual operating temperatures and pressures

The operating temperature and pressure conditions for each mode of operation and occurrence needs to be documented. The procedures required should detail the recorded pressures and temperatures of each CPS and provide direction on the retention of this information.

D. Documentation of significant system transients or excursions including thermal hydraulic events (e.g., steam hammers, liquid slugging)

System transients and excursions should be documented along with any analysis or inspections done to determine if any damage may have occurred. The procedures required should define when transients and excursions need to be further investigated.

E. Documentation of modifications, repairs, and replacements

All modifications, repairs, and replacements to the CPS need to be recorded, including the reasons that these activities were necessary. This should include any failure analysis reports. The required procedures should address the need to protect any failure locations until adequate information and samples can be taken for analysis.

F. Documentation of maintenance of pipe supports for piping operating within the creep regime

Similar information as required for the modification, repairs and replacements of the CPS should also be recorded for the support systems on the CPS. This should also include the information on the hanger settings found during CPS walkdowns.

G. Documentation of maintenance of piping system elements such as vents, drains, relief valves, desuperheaters, and instrumentation necessary the safe operation

Similar information should also be recorded for the auxiliary elements of CPS which may be a factor in safe operation. The procedures required should address any failure and the repair or replacement of these elements.

H. Assessment of degradation mechanisms, including, but not limited to, creep, fatigue, graphitization, corrosion, erosion, and flow accelerated corrosion (FAC)

The analysis and assessment of the condition of the CPS with regard to known degradation mechanisms, including new degradation mechanisms reported by the industry, should be recorded. The determination of the areas to be assessed for these degradation mechanisms should be addressed within the required procedures as should any analysis of detected problems.

I. Quality of flow medium (e.g., dissolved oxygen, pH)

The chemistry of the flow medium must be maintained within specified limits in accordance with required procedures for each CPS.

J. Documentation of the condition assessment (see para. 140)

The overall program control, including record retention, should be addressed within the required procedures. This should provide a basic explanation of the program for use by new employees to familiarize them with the required aspects of the CPS condition assessment program.

K. Other required maintenance

As found necessary.

### *3.1.3 Program*

As a minimum, the piping systems included within the definition of CPS (item 1.3) are required to be covered within the program established by each Operating Company. The requirements of the program are detailed in item 2.1.2. Additional piping systems or subsystems may also be included at the discretion of the Operating Company.

Appendix V of B31.1 may be used to guide the Operating Company on the issues that must be included and those which may also be included.

The intent of the program is to provide information needed to assess the condition of the piping systems that are considered to be significant to their safety and reliability. Should any maintenance or failures occur, this information may be used to develop the maintenance or repair needs and to consider the effects of the maintenance or repair on the continued safety and reliability of the system. The program also is intended to provide the tools needed to access the continued operation should any significant operational transients beyond the design occur.

### *3.1.4 Record Keeping*

Though not specifically addressed in the new chapter, a recommended guideline for maintaining and performing the program is the establishment of a CPS Condition Assessment file. The file type is the prerogative of the Operating Company (digital with backup hard copy is suggested) but the file should be kept on site for the life on the unit. Experience has shown that having the piping system information readily available will greatly reduce the amount of effort required to perform the periodic condition assessments. This will also prove to be invaluable in the event of an emergency repair following a piping failure. The CPS Condition Assessment file should include the fabrication and construction data reports (P4 or P4A forms) for the boiler external piping.

## 3.2 Application of CPS Program

### *3.2.1 Assessment Period*

The B31.1 Chapter VII requirements intentionally do not specify the period between the condition assessments. This is the responsibility of the Operating Company based on issues such as the criticality of the system, the previous condition assessments, any operating transients noted, outage schedules, industry failure history, and confidence in the manufacturing and fabrication. The intent is that the period may need to vary based on such issues to be more or less than a standard period. The period may also be changed based on increasing or decreasing concerns for the condition of the individual system.

### *3.2.2 Retroactive Application*

While not required by the ASME Codes to be applied to systems that were contracted for prior to the 2007 edition of B31.1, it may be possible to apply the requirements to existing systems, either by choice or by regulatory imposition. In this case, the prerequisite records and data may not be entirely available. Where information is unavailable and the requirements of Chapter VII are being made retroactively, only the available documentation is required, although new information based on additional analysis should be added if it becomes available. As with the requirement for the systems where the code of reference is the 2007 edition of B31.1 (or later), the intent is that the safety and reliability of the system is maintained.

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