Use of ASME B31.3 Piping as AG-1 Duct

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The Hanford Nuclear Reservation includes 177 underground tanks, organized in 18 “tank farms” storing over 200 million liters (56 million gallons) of mixed high-level waste (HLW). The waste contains millions of curies of radioactive materials, hydroxide, solvents, cyanides, and toxic metals. These tanks continue to contain waste well past their design life. Use of active ventilation system is required any time the waste is to be disturbed, including when the waste is subject to retrieval, transfer, chemical addition, water addition, and sampling.

The use of ASME B31.3 piping in lieu of ASME AG-1 Article SA (Code on Nuclear Air and Gas Treatment) for ductwork requirements has eased the design of ventilation system ductwork at the Department Of Energy’s (DOE) Hanford Nuclear Reservation (Hanford site).

PURPOSE

This report discusses the technical basis for evaluating national consensus codes including, ASME B31.1, B31.3, B31.9, AG-1, used for ductwork of waste tank ventilation systems at the Hanford site and identifies selected code requirements that impact design and construction cost.

BACKGROUND

The Hanford site (Figure 1) is managed by the U.S. Department of Energy (USDOE). It lies within the semiarid Pasco Basin of the Columbia Plateau in southeastern Washington State. The Hanford Site encompasses approximately 1,450 km^2 (560 mi^2) north of the confluence of the Yakima and Columbia Rivers.

Established in 1943, the Hanford Site was originally designed, built, and operated to produce plutonium for nuclear weapons. The plutonium was produced by irradiation of uranium fuels in nine nuclear reactors, with the plutonium chemically separated from the spent fuel. The major waste generating processes at Hanford have been the chemical separations process facilities including:

- Bismuth Phosphate/Lanthanum Fluoride
- Reduction-Oxidation (REDOX)
- Plutonium-Uranium Extraction (PUREX)
- Uranium Recovery (UR)
- Plutonium Finishing Plant (PFP)
- Uranium Trioxide (UO3)
- Strontium/Cesium separations and recovery

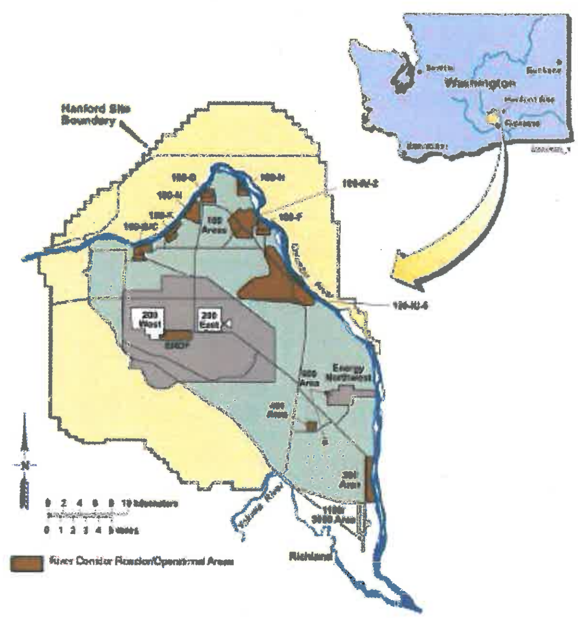


Figure 1. Hanford Site Map

- Rare Earth metals recovery
- Americium Recovery
- Various Neptunium, Thorium, Lithium/Tritium process operations.

Hanford's spent fuel processing has generated several hundred thousand metric tons of liquid chemical and radioactive wastes. Included were HLW, transuranic (TRU) waste, and Low-Level and Mixed Low-Level Wastes (LLW/MLLW) wastes. The waste management process initially involved routing the HLW and TRU wastes for neutralization with sodium hydroxide and sodium carbonate and storing the resulting waste mixture in large underground tanks. From 1943 through 1986, 149 Single-Shell Tanks (SSTs) and 28 Double Shell tanks (DSTs) were built to store waste at Hanford (Figures 2, 3, 4, and 5).

Figure 6 and Figure 7 show two configurations of Hanford DST tank farm ventilation systems.

REGULATORY REQUIREMENTS

Environmental requirements are driven by Washington state and federal regulations, permits, the Hanford Federal Facility Agreement and Consent Order (HFFACO aka Tri-Party Agreement) and associated enforceable documents, compliance inspection resolution agreements, and other agreements between the Department of Energy and environmental regulatory agencies.

The air quality standards are set by both the Washington State Department of Ecology (Ecology) and the Washington State Department of Health (Health). Health has jurisdiction of radionuclide emissions; while Ecology has jurisdiction for criteria and toxic air pollutant emissions. The primary regulations covering radioactive emissions at Federal Facilities are Washington Administrative Code (WAC) 246-247, Radiation Protection, Air Emissions, WAC 173-480 Ambient Air Quality Standards and Emission Limits for Radionuclides.

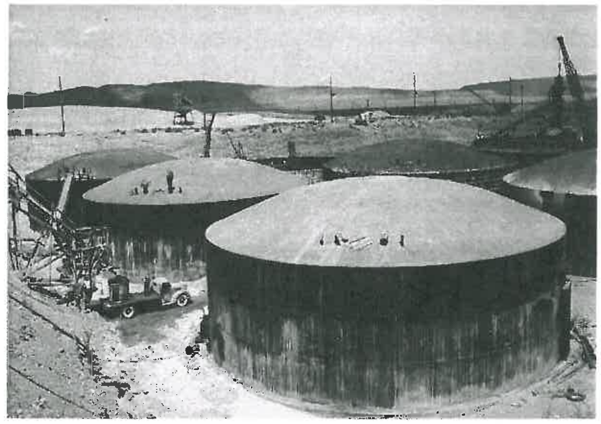


Figure 2. Construction of the BY Farm SSTs in 1949

Figure 3. Construction of the AW Farm DSTs

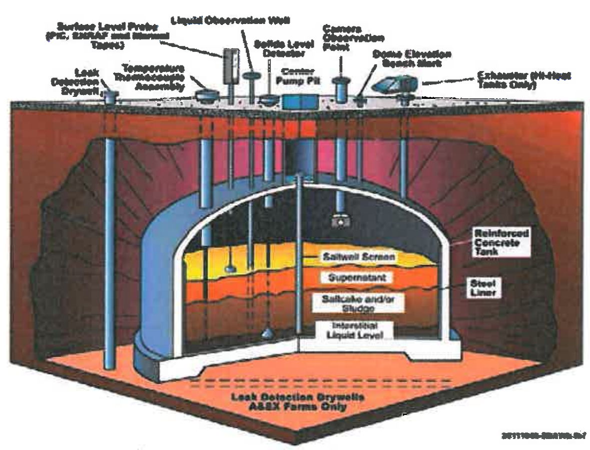


Figure 4. Configuration of SSTs in 1979

The regulations require the use of best available radionuclide control technology (BARCT).

The expectation is that these and other applicable standards will be clearly identified and implemented. ASME/ANSI AG-1, Code on Nuclear Air and Gas Treatment and Energy Research and Development (ERDA) 76-21, Nuclear Air Cleaning Handbook, and the American Conference of Governmental Industrial Hygienists (ACGIH) 1988, Industrial Ventilation, *A Manual of Recommended Practice*, have been identified as industry standards for designing ventilation systems at Hanford site.

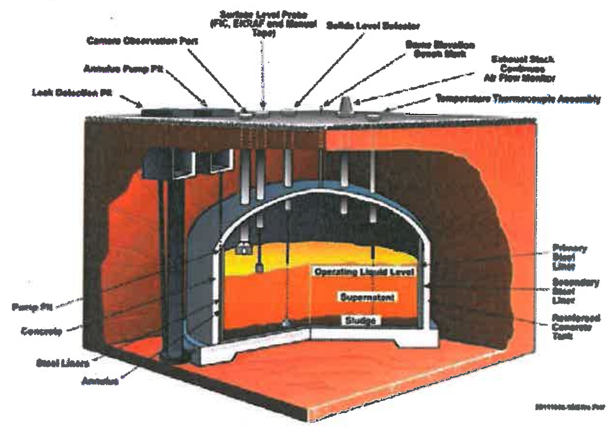


Figure 5. Configuration of DSTs in 1979

In addition, the Department of Energy (DOE) Office of River Protection (ORP) requires Hanford Contractors to apply DOE-HDBK-1169, Nuclear Air Cleaning Handbook, as a guidance for using AG-1 for the design of ventilation systems.

Figure 6. Configuration of 241 AN in 2008

Hanford Tank Farms' Documented Safety Analysis (DSA) Chapter 3 identifies that small quantities of waste may be present in the active ventilation systems associated with the DSTs and SSTs. Actual quantities are unknown, but for accident analysis purposes conservative quantities and compositions are assumed. Some residual waste may be present in waste transfer associated structures connected to the DST and SST waste transfer systems from past waste leaks.

Figure 7. Configuration of 241 AP in 1979

JURISDICTIONAL BOUNDARIES

The ASME B31 and AG-1 codes for Pressure Piping/Ductwork consist of a number of individually published codes that are American National Standards. The rules reflected in each code are driven by the type of process system being designed. This report describes the jurisdictional boundaries of ASME B31.1, B31.3, B31.9, and AG-1.

METHODOLOGY

ASME AG-1, Code on Nuclear Air and Gas Treatment, relies largely on the ASME Boiler and Pressure Vessel Code (BPVC) Section III, Rules for Construction of Nuclear Facility

Components. AG-1 calculates material stresses based on the average membrane stress and bending stress similar to the Section III methodology and uses BPVC Section II Material Property Tables specified for Section III analyses. To demonstrate the applicability of the TOC ASME B31.3 ventilation system analysis method, one may compare the results from an ASME B31.3 piping analysis of a typical ventilation system to the results from an ASME BPVC Section III piping analysis of the identical system. Autopipe® allows for Section III, Division 1, Subsection ND (Class 3 piping) analysis which is used for this comparison. In addition, design analysis requirements of stresses due to sustained, thermal, and occasional loads (load combinations as determined by AISC 7). Calculation comparisons are used as a method for determining the suitable code amongst ASME piping codes and AG-1 (SA). The occasional loads consisted of wind and seismic loads as determined by the methods in AISC 7.

It is notable that the "Companion Guide to the ASME Boiler and Pressure Code" (2012) states that Section III, Class 3 piping rules are most like those in contained ASME B31.1, Power Piping. However, due to the pressure ranges and ventilation exhaust stream constituents of typical Hanford ventilations systems, use of the Power Piping Code is contraindicated. The Power Piping Code is designed to have a higher degree of reliability due to the hazards involved in the power plant systems.

The ASME B31.3 Process Piping Code is appropriate considering the hazard level and cyclic and occasional loadings. The fluid services categories and temperature and pressure ranges within the ASME B31.3 Process Piping Code are sufficient to cover the design range of the typical Hanford ventilation systems.

This report also compares assessed stress allowable, materials, minimum weld examination, and compliance with primary air quality standard and radionuclide emission regulatory requirements for maintenance of confinement and containment of radionuclides present in the waste tanks for supporting ASME B31.3 use for designing ductwork.

RESULTS

The system depicted in Attachment A is used to support the use of ASME B31.3 as AG-1 compliant ductwork. The system is being installed to upgrade the ventilation system of the Hanford 241-AP Farm. New filter trains, moisture separators and exhaust fans are being installed to replace and upgrade existing equipment to comply with ASME AG-1 and ASME B31.3 as required by the Washington Administrative Code WAC 246-247. The system depicted is constructed using 12" NPS Schedule 10S, ASTM A312, type 304L pipe as the duct material.

The differences in the ASME B31.3 and the Section III, Division 1, Subsection ND code stress outputs do not allow for a direct one-to-one comparison of stresses/allowables for the Code-defined sustained, thermal and occasional load cases, but demonstrate similar stress profiles and comparable stress ratio results:

- Autopipe® ASME B31.3 code output reports hoop stress (max pressure case), the sustained load case (dead loads plus internal pressure), expansion stresses due to thermal, and the occasional load case (sustained loads plus earthquake/wind).
- Autopipe® Section III, Division 1, Subsection ND code stress output reports include sustained (internal pressure only), thermal stresses, and occasional loads (seismic/wind only).

The two Codes use different equations for stress and flexibility calculations, and different Stress Intensification Factors (SIF) for modeled elements, obviously resulting in different calculated stresses and specified allowables. The Stress Indices, Flexibility and SIFs for an ASME B16.9 welding tee used in the present design, for example, appears in ASME BPVC Sect. III Div. 1 Section ND-2015 Table ND-3673.2(b)-1. The applied pressure of 10 psig results in a stress ratio of 95% of the Sect. III allowable, while the B31.3 sustained load (pressure plus dead load) results show a 67% of allowable result at the same location. The ASME B31.3 analysis produced a more conservative result than Section III relative to the respective Code allowables for sustained loadings.

Based on the above computer models, stress and flexibility it is concluded that ASME B31.3 piping used as ductwork meets and exceeds the ASME AG-1 service levels for the 241 AP DST ventilation systems ductwork. Although each Code provides a set of requirements for obtaining a safe, reliable, and economical installation the results show that use of ASME B31.3 provides an adequate protection against loss of confinement and containment during normal and off normal operations and regulatory requirements.

DISCUSSION

All Hanford underground tanks are provided with access via a number of carbon steel piping (tank risers) for the ventilation of the tank primary and annulus spaces. All risers used for ventilation are provided with flanges above grade. Construction of the tanks and risers is compatible with the ASME piping materials. Due to presence of waste constituents and stringent leak tight requirements, ASME B 31.3 piping has been chosen for waste transfer piping and ductworks for transferring and ventilating radioactive aerosols.

Selection of inappropriate codes, standards, and requirements could add to the cost of design and construction. Thus, structural assessment comparison of ASME B31.1, B31.3, B31.9 and AG-1 (SA) Piping/Ductwork is needed to ensure design features are considered for meeting the safety codes. The following topics are discussed:

- Jurisdictional boundaries of each code,
- Code stamping and quality control,
- Design analysis requirements,
- Design pressure/temperature conditions/allowable pressure variations above design pressure,
- Minimum weld examination requirements,
- Minimum pressure testing requirements, and
- Design pressure ratings of flanges.

ASME B31.1, POWER PIPING

This power piping code covers boiler external piping for power boilers and high temperature, high pressure, water boilers in which steam or vapor is generated at a pressure greater than 15 psig, and high temperature water is generated at pressures exceeding 160 psig, and/or temperatures exceeding 250°F. This code includes, but is not limited to, steam, water, oil, gas, and air services.

ASME B31.3, PROCESS PIPING

The process piping code applies to piping systems found in petroleum refineries, chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants, and related processing plants and terminals.

This code excludes piping systems designed with internal gage pressures at or above zero but less than 15 provided the fluid is nonflammable, nontoxic, and not damaging to human tissue, and its design temperature is –20 to 366°F. The code addresses Normal Service piping, Category D piping, Category M piping, High Pressure piping, nonmetallic piping, and piping for severe cyclic conditions.

ASME B31.9, BUILDING SERVICES PIPING

This code applies to piping in industrial, institutional, commercial, and public housing and multi-unit residences. The code does not cover the range and sizes, pressures, and temperature covered in ASME B31.1. B31.9 piping is typically found in building services ranging up to 350 psig/250°F maximum. The code also covers boiler external piping for steam boilers with 15 psig maximum pressure and water heating units with 160 psig maximum pressure and 250°F maximum temperature. The code pipe size is limited to 30-in. nominal pipe size and 0.5 in. wall thickness for carbon steel. Stainless-steel pipe is limited to 12-in. nominal pipe size and 0.5 inch wall thickness. Thermoplastics are limited to 14-in. nominal pipe size. This code allows the use of nonmetallic piping systems.

ASME AG-1

This Code provides requirements for the performance, design, fabrication, installation, inspection, acceptance testing, and quality assurance of equipment used in air and gas treatment systems in nuclear facilities.

This Code applies only to individual components in a system. This Code does not cover any functional system design requirements or sizing of complete systems, nor any operating characteristics of these systems. The responsibility for meeting each requirement of this Code is assigned to the Owner or assigned designee.

The requirements of AG-1 for air and gas treatment components may be used for engineered safety feature systems and normal systems in nuclear power generation facilities, and for air cleaning systems in other nuclear facilities. The design and procurement specifications delineate the design, qualification and quality assurance requirements appropriate for the application.

CODE STAMPING AND QUALITY CONTROL

The following sections explain code stamping and quality control.

GENERAL REQUIREMENTS

ASME B31.1 requires manufacturers/contractors installing boiler external piping by welding or brazing to provide a data report, inspection, and stamping per ASME Boiler and Pressure Vessel Code, Section I.

ASME B31.3 requires that the owner have overall responsibility for compliance with this code and for establishing the requirements for design, construction, examination, inspection and testing. The owner is responsible for designating piping fluid services and determining a specific Quality System.

ASME B31.9 does not address stamping of piping systems. Quality control systems are not required by this code. Appendix E of the code provides direction on quality control systems if required by the owner.

ASME AG-1 requires that the owner have overall responsibility for compliance with this code and for establishing the requirements for design, construction, examination, inspection and testing. The owner is responsible for designating determining a specific Quality System.

Article AA-8000 of ASME AG-1 defines quality control requirements for components, parts, and equipment. In addition, the requirements of ASME NQA-1 apply to the component, parts, and equipment covered by AG-1.

DESIGN ANALYSIS REQUIREMENTS

ASME B31.1, B31.3, B31.9, and AG-1 require similar analysis for a piping systems such as minimum wall thickness, stresses due to sustained loads, thermal expansion, occasional loads, hanger stresses due to piping loads, and branch reinforcement stresses when applicable.

COMPARISON OF CODE DESIGN STRESS ALLOWABLE

Table 1 shows the differences in carbon steel allowable stresses for the various codes addressed by this paper. This table shows the conservatism for the different codes.

Table 1. Allowable Stress for ASTM A106, Grade B.

Code	Allowable
B31.1[1]	17,100 psi
B31.3[3]	20,000 psi
B31.9[2]	17,100 psi
AG-1[4]	17,100 psi

1) Per ASME B31.1, Table A-1, up to 650°F for sustained loads.
2) Per ASME B31.9, Table I-1, up to 400°F for sustained loads.
3) Per ASME B31.3 Table A-1, up to 300°F
4) Per ASME AG-1, primary allowable stresses developed in the ASME Code, Section III, Division 1, Subsection NF-3322.1 through NF-3322.8, up to 650°F.

The ASTM A106 Grade B material has a 60,000 psi tensile and a 35,000 psi yield strength. This carbon steel grade is used as an example for the differences in allowable stress by the evaluated ASME Codes.

For occasional loads the maximum allowable tensile stress (shown in Table 2) increased by Occasional loads are defined in ASME B31.9, para. 902.3.3, as wind, (or snow, ashfall) or earthquake loads.

Table 2. Occasional Stress Allowance.

Code	Allowance Factor
B31.1[1]	1.15 or 1.2
B31.3[2]	1.33 or 1.2
B31.9[3]	1.33
AG-1[4]	1 or 1.5

1) Per ASME B31.1,
2) Per ASME B31.3,
3) Per ASME B31.9, paragraph 902.3.3.
4) Per ASME AG-1, Table AA-4321, depends on Service Level

DESIGN PRESSURE, TEMPERATURE CONDITIONS, AND ALLOWABLE PRESSURE VARIATIONS ABOVE DESIGN PRESSURE

ASME B31.1/B31.3 criteria for design pressure require this pressure to be not less than the maximum sustained operating pressure. Design temperature is the maximum sustained temperature condition expected.

ASME B31.9 criteria for design pressure require the pressure to be equal to or greater than the maximum sustained fluid operating pressure in the piping system.

ASME AG-1 criteria for design pressure require the pressure to be equal to or greater than the maximum steady state operating pressure.

LOAD COMBINATIONS

B31 Codes

Load combinations are used in the analysis for all B31 codes usually include the following from ASCE 7-10. Note: Sections below are extracted verbatim from ASCE 7-10.

Basic Combinations

Loads listed herein are considered to act in the following combinations; whichever produces the most unfavorable effect in the building, foundation, or structural member being considered.

EXCEPTION: The most unfavorable effects from both wind and earthquake loads shall be considered, where appropriate, but they need not be assumed to act simultaneously.

Increases in allowable stress shall not be used with the loads or load combinations given in this standard unless it can be demonstrated that such an increase is justified by structural behavior caused by rate or duration of load.

LOAD COMBINATIONS INCLUDING ATMOSPHERIC ICE LOADS

For the analysis of piping, the ASME B31.1, B31.3 and B31.9 piping codes are typically used. The piping codes are based upon an "Allowable Stress" basis. Therefore, the load combinations from ASCE 7-10, section 2.4 "Combining Nominal Loads Using Allowable Stress Design" are to be used.

The piping code stress allowable for the above cases is S_a per the respective piping code and not 1.33 x S_a. (S_a is the basic stress allowable at the design temperature). Note, alternate load case definitions should be developed if the 1.33 x S_a allowable is used, e.g., in an AutoPIPE analysis.

STRUCTURAL LOADS FOR THE AG-1 DUCTWORK

For analysis of ductworks, ASME AG-1 uses ASME Code Section III for primary allowable stresses for loads that are similar to ASME B31.1, B 31.3, and B31.9 as identified in AA-4200 Design Criteria, based on the Service Limits for structural capabilities to meet facility specific requirements. The maximum normal stress limits for the loading combinations are:

$\sigma_1 \leq 1.0S$ and $\sigma_1 + \sigma_2 \leq 1.5S$ where S = Design stress value from Article AA-3000 references

σ_1 = membrane stress and σ_2 = bending stress

Table 3 shows the ASME AG-1 Service Level load conditions for designing ductwork.

Table 3. ASME AG-1 Load Combination

Service Level[5]	Category	Load Combination	Stress Criteria
A	Normal Condition	NOPD[6]+DW+EL+FML+T, and NOPD[6]+DW+EL+FML+T+L	(1,4)
B	Normal Condition	NOPD+DW+EL+FML+W+T, and NOPD+DW+EL+FML+OBE+T+ADL	(1,4)
C	Emergency Condition	NOPD+DW+EL+FML+W+T, and NOPD+DW+EL+FML+SSE+ADL	(2)
D	Faulted Condition	NOPD+DW+EL+FML+DPD+SSE+ADL	(3)

1) The basic general membrane design stress for Service Level A or B condition does not exceed 1.0 S_a and is reduced as appropriate to account for lateral-torsional buckling of bending members and effective lengths of compression members. The combined membrane and bending stress for Service Level A or B does not exceed 1.5 S_a. The basic general membrane stress for Service.

2) Level C condition does not exceed 1.2 S_a and is reduced as necessary to account for lateral-torsional buckling of bending members and effective lengths of compression members. The combined membrane and bending stress for Service Level C does not exceed 1.8 S_a.

3) Level D condition does not exceed 1.5 S_a and is reduced as necessary to account for lateral-torsional buckling of bending members and effective lengths of compression members. The combined membrane and bending stress for Service Level C does not exceed 2.25 S_a, see also Table AA-4321.

4) The allowable deflections for the load combinations described above are provided in Section SA-4230.

5) Service Levels are defined in ASME AG-1 Section AA-4214.2.

6) Normal Operating Pressure Differential (NOPD): the maximum positive or negative pressure differential that may occur during normal plant operation, including plant start-up and test conditions; included are pressures resulting from normal airflow and damper or valve closure.

MINIMUM WELD EXAMINATION REQUIREMENTS

Note: In these codes, inspection is an activity performed by the owner; examination is an activity performed by the fabricator.

ASME B31.1 requires visual examination for all pipe welds below 350°F and 1,025 psi pressure. Pressures over 1,025 psi and temperatures between 350 and 750°F require radiography or ultrasonic inspection for pipe over 2 in. NPS and 0.75-in. wall per Table 136.4 of ASME B31.1.

ASME B31.3 for Normal Service required 5 percent visual examination for weld fabrication for each welding machine and weld operator. Longitudinal welds require 100 percent visual examination. Random visual examination of bolted and threaded joints and 5 percent random radiography/ultrasonic examination of circumferential butt and miter joints are required.

ASME B31.3 for Category D service requires random visual examination at the examiners discretion.

ASME B31.3 for Category M piping is the same as Normal service with the following exceptions: Visual examination is 100 percent for all fabrication, and all threaded, bolted, and mechanical joints. Random radiography/ultrasonic examination is 20 percent for circumferential butt and miter welds and fabricated lap and branch connections welds (see M341.4 for details).

ASME B31.3 for High Pressure piping in Chapter IX is the same as Normal Service except that visual examination is 100 percent for materials and components, all fabrication, all threaded, bolted and other joint configurations, and piping erection. Pressure containing threads require 100 percent visual examination. Radiographic examination is 100 percent for all girth, longitudinal, and branch connections.

ASME B31.9 requires visual inspection only.

ASME AG-1 requires inspection and testing of welds shall be performed in accordance with Articles AA-5300 and Article AA-6000.

MINIMUM PRESSURE TESTING REQUIREMENTS

In general hydrostatic testing is a leak test and not necessarily a structural qualification test.

ASME B31.1 hydrostatic testing is with water at 1.5 times the design pressure but shall not exceed the maximum allowable test pressure of any non-isolated components and the stress requirements of 102.3.3.b of the code (hoop stress not to exceed 90 percent of yield strength at test temperature; longitudinal stresses because of test pressure, live load, and dead loads not to exceed 90 percent of yield strength at test temperature).

ASME B31.3 hydrostatic leak tests are with water and are not less than 1.5 times the design pressure. The test pressure shall not produce pressure stresses or longitudinal stresses above the yield strength of the material.

ASME B31.9 hydrostatic testing is at 150 percent of the design pressure with the pressure stress not to exceed 90 percent of the yield strength of the material or 1.7 times the SE (allowable stress/weld efficiency factor) value for brittle material. The hydrostatic test shall be performed for 10 minutes. A leak check shall be made following the hydrostatic test.

Initial service leak tests for gas, steam and condensate services not over 15 psig, and nontoxic, noncombustible, nonflammable liquids at pressures not over 100 psig and temperatures not over 200°F is permissible. The piping system may be brought up to operating pressure with visual examination at pressures of 1/2 and 2/3 of design pressure. A final visual examination shall be made at operating pressure.

ASME AG-1 requires a Structural Capability Test (See SA-5400) and a Pressure Boundary Leakage Test (see SA-5300).

Structural Capability Test per TA-3522, "Testing shall be conducted in accordance with the design codes used in the owner's design specification (e.g., ASME B31.1)". Testing shall be conducted in accordance with Mandatory Appendix TA-II.

Pressure Boundary Leakage Test per TA-3400 with allowable leakage determination per SA-4532.

PIPE FLANGE PRESSURE RATINGS

Pipe flanges are rated at pressures from 150 psig to 2,500 psig. The pressure rating is a function of temperature and material groups. The rating of the flange (i.e., 150 psig) is not the maximum allowable pressure for this flange. A 150-psig-rated flange carries this rating at a temperature equal to about 600°F. At 100°F this flange could be rated as high as 275 psig. Other flange ratings show a comparable trend (i.e., 300 psi, 400 psi). Note that a 150-psi-rated flange for a group 2.3 material (230 psi working pressure) at 100°F does not have the same working pressure rating as a 150-psi-rated flange for a group 2.2 material (275 psig working pressure) although they are both stainless steel per ASTM A 240. Refer to ASME B16.5 or tabulated values of working pressures versus temperature for various material groups and pressure classes.

CONCLUSIONS

Based on the computer analysis of model stress and flexibility, it is concluded that ASME B31.3 piping meets the ASME AG-1 applicable service level for the DST ventilation systems ductwork. Each Code provides a set of requirements for obtaining a safe, reliable, and economical installation the results show that use of ASME B31.3 provides an adequate protection against loss of confinement and containment during normal and off normal operations and regulatory requirements. Similar calculations with similar results have been performed for other facility ductwork and configurations. This result combined with the other stringent ASME B31.3, e.g., zero leakage, weld and weld inspection, similarity in materials, and pressure testing, and inspection requirements, inspection requirements, provide a defendable technical basis for use of the ASME B31.3 piping code for designing ductworks. Furthermore, ASME B31.3 provides a better protection against corrosive waste presence in the piping systems and maintaining adequate confinement and containment barriers for protection of the workers and environment due to waste leaks.

Pipe and piping components used for Hanford ventilation systems are 300 series stainless steel and comply with ASME B31.3 as allowed by AG-1, AA-3000 Table AA-3100. ASME B 31.3, "Process Piping," Appendix A, listing of piping materials for the ventilation systems are equivalent to ductwork materials in ASME AG-1, AA-3000, SA, "Materials."

ASME B31.3 Code meets Duct Class 4 and 5 (Zero detectable leak at any pressure up to 20 in. w.g.) per ERDA 76-21 Table 5.6. Design of duct work per the requirements of ASME B31.3 piping is permissible per ERDA 76-21 and complies with ASME AG-1 Section SA design requirements. Furthermore, DOE HDBK-1169-2003, Sec. 5, "External Components", requires that ductwork to meet leak tightness requirements of zero detectable leak at any test pressure up to 20 in. w.g. (water gauge) for level five duct (Table 5.6), or pipe meeting requirements of American National Standard for pressure Piping, e.g. ASME B 31.1, B31.3, ASME B31.5, ASME B31.9 to name a few. etc., or the ASME Boiler and Pressure Vessel Code (B&PV), Section VIII.

REFERENCES

1. 10 CFR 830, Nuclear Safety Management.

2. 40 CFR 61, National Emission Standards for Hazardous Air Pollutants," Subparts H and I, "National Emission Standard for Radionuclide Emissions from Department of Energy Facilities.

3. American Conference of Governmental Industrial Hygienists (ACGIH) 1988, Industrial Ventilation.

4. ASCE 7-10, Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers (ASCE).

5. ASME AG-1-2015, "Code on Nuclear Air and Gas Treatment", American Society of Mechanical Engineers, New York, New York.

6. ASME B31.1, 2014, "Power Piping", American Society of Mechanical Engineers, New York, New York.

7. ASME B31.3, 2014, "Process Piping", American Society of Mechanical Engineers, New York, New York.

8. ASME B31.9, 2014, "Building Services Piping", American Society of Mechanical Engineers, New York, New York.

9. DOE-HDBK-1169-2003, "Nuclear Air Cleaning Handbook: Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application," fourth edition.

10. ERDA 76-21, Nuclear Air Cleaning Handbook

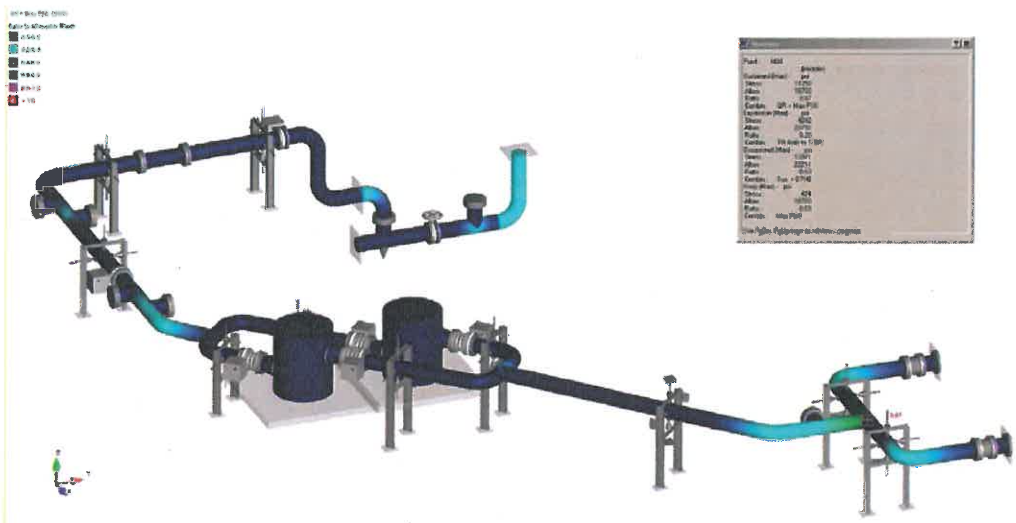
11. WAC 173 Ecology, Department Of; Chapter 303 – "Dangerous Waste Regulations", Chapter 400 – "General Regulations for Air Pollution Sources", Chapter 401, "Operating Permit Regulation", Chapter 460 – "Controls For New Sources of Toxic Air Pollutants", and Chapter 480 – "Ambient Air Quality Standards and Emission Limits for Radionuclides."

12. WAC 246-247, Radiation Protection – Air Emissions

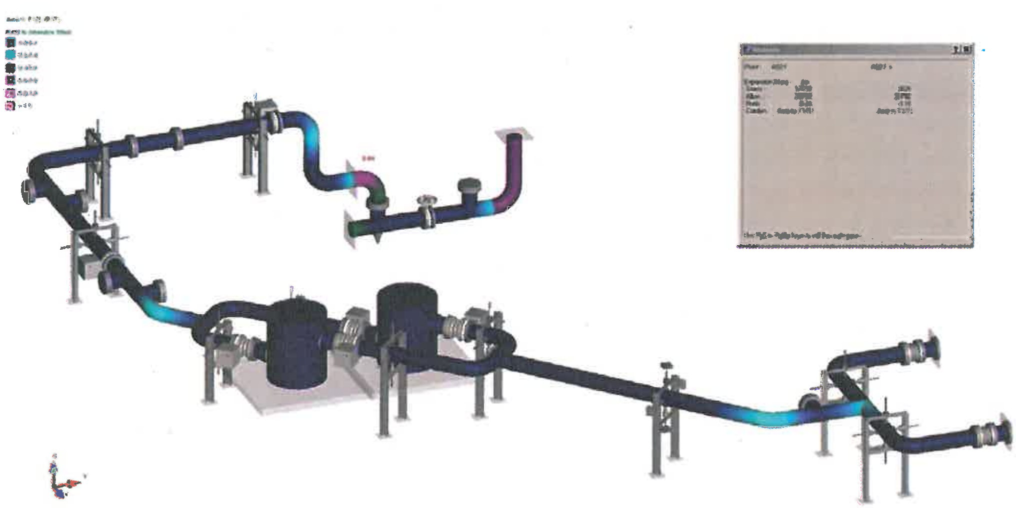
13. WAC 246-247-120 – Appendix B, BARCT Compliance Demonstration

ATTACHMENT – VENTILATION MODEL RUN CASES

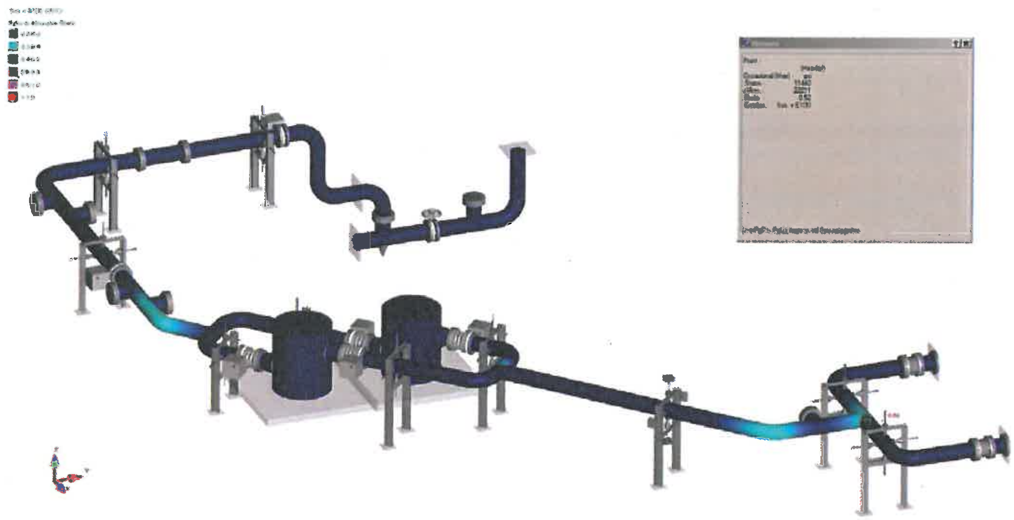
Case – B 31.3 Sustained Load Case (DL+P)



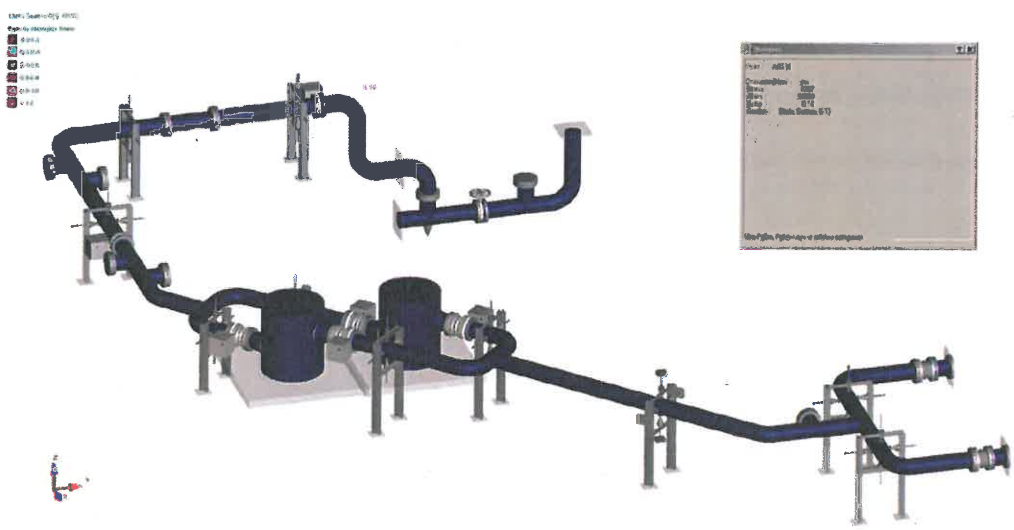
Case – B&PV SEC III Sustained Load Case (P=10 psi)



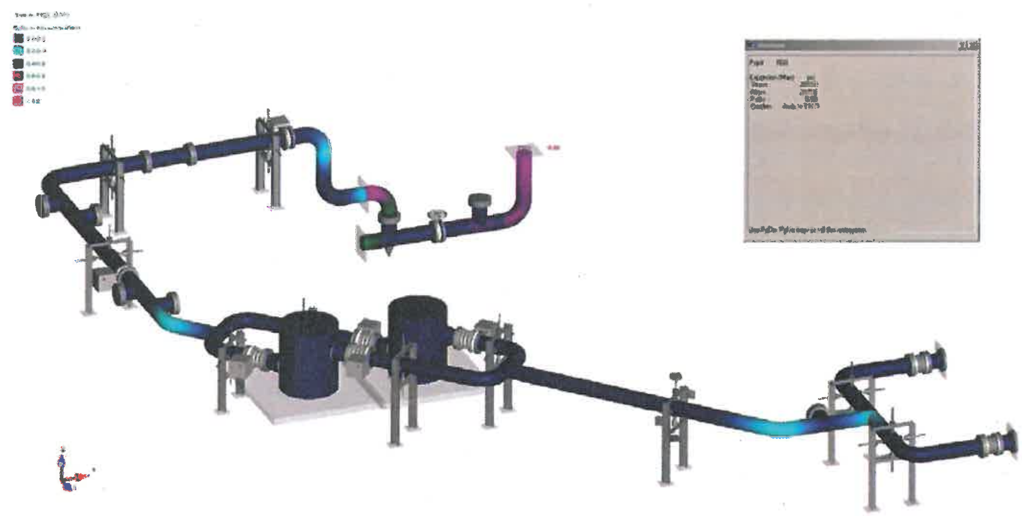
Case – B31.3 Occasional Load Case (SUS + E/W)



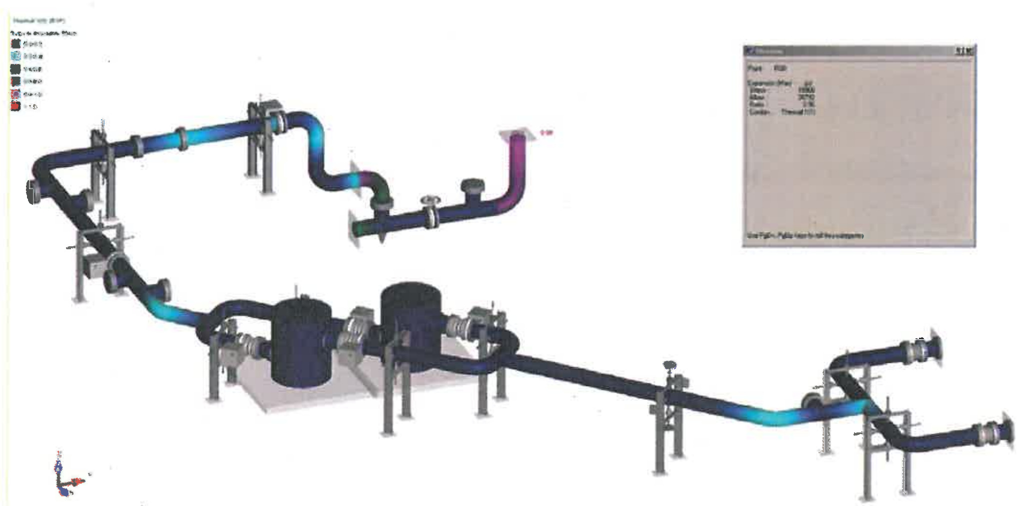
Case – B&PV SEC III Occasional Load Case (Earthquake Loads)



Case – B31.3 Thermal Load case (T=195°F)



Case – B&PV SEC III Thermal Case Load (T=195°F)



Case – B31.3 Hoop Stress Case (P=10 psi)