

DEP SPECIFICATION

PIPING – PIPE STRESS ANALYSIS REQUIREMENTS

DEP 31.38.01.26-Gen.

February 2019

DESIGN AND ENGINEERING PRACTICE

DEM1



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for completing the pipe stress analysis for piping systems built in accordance with ASME B31.3 and pipeline facilities (pump stations, compressor stations, valve stations, pig stations) built in accordance with pipeline codes such as ISO 13623, ASME B31.4, ASME B31.8, NEN 3650 and PD 8010. It applies to piping for all types of process fluids (including fluidised solids), and all utility fluids.

Piping covered under equipment design codes is excluded from the scope of this DEP.

Oil and gas risers, hull piping subjected to Classification Society rules (except for piping associated with topsides process systems), subsea piping systems, utility piping in livingquarters and plant buildings are excluded from the scope of this DEP.

Cross-country sections of pipelines - with the exception of pipeline facilities - designed in accordance with codes such as ISO 13623, ASME B31.4, ASME B31.8, NEN 3650 and PD 8010 are excluded from the scope of this DEP. Sketches of the interface between pipelines and other equipment are included in ASME B31.8 and ISO 13623. See also DEP 31.40.00.10-Gen.

Piping fabrication requirements are covered in DEP 31.38.01.31-Gen.

Piping systems of "boiler proper piping" as referenced in ASME B31.1, Section 100.1.1 are covered by ASME Section I.

Piping systems of "boiler external piping" (steam, feed water and blow down piping systems) as referenced in ASME B31.1, Section 100.1.1 are covered by ASME B31.1.

Piping systems for package refrigeration units are covered by ASME B31.5, except that impact test requirements are covered by DEP 30.10.02.31-Gen.

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a new DEP that has been developed in the course of splitting the content of DEP 31.38.01.11-Gen.; see (1.5) regarding the change.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions – General

Term	Definition
Deadleg	Components of a piping system that normally have no significant flow. Some examples include blanked branches, lines with normally closed block valves, lines with one end blanked, pressurized dummy support legs, stagnant control valve bypass piping, spare pump piping, level bridles, relief valve inlet and outlet header piping, pump trim bypass lines, high-point vents, sample points, drains, bleeders, and instrument connections.
Execute phase	Detailed engineering and implementation stage of the project
Flowline	Piping which carries well fluid from wellhead to manifold or first process vessel
flashing fluid	Fluids listed in Energy Institute IP 15 as Class 0, I, II (2) and III (2). Where warm/hot surfaces are within the distances defined in API RP 505:2018, section 14.3, fluids listed as Class II (1) and III (1) also are included.
fluid	gas, vapour, liquid or combinations thereof
hydrogen service (H2 service)	Service in which the hydrogen partial pressure is greater than 700 kPa absolute (100 psia) at any temperature. See also API RP 941:2016, Figure 1.
long-run piping	Piping with length more than one pipe support span
pipe stress engineer	Engineer approved by the Principal to undertake pipe stress analysis for a project. The engineer is responsible for obtaining data from disciplines as appropriate, creation, maintenance and issue of the pertinent pipe stress analysis documentation detailed within this standard, analysis and approval of all stress critical lines and the timely dissemination of pipe support/restraint information

Term	Definition
pipe track	Piping route typically consisting of multiple pipes, where pipes are routed at grade level using concrete sleepers as pipe supports
Pipeline	System of pipes and other components used for the transportation of fluids between (but not within) plants. A pipeline typically extends from pig trap to pig trap (including the pig traps). If no pig trap is fitted, the pipeline extends to the first isolation valve within the plant boundaries.
Piping class	Assembly of piping components, suitable for a defined service and design limits, in a piping system. The piping classes are contained in the following DEP binders: DEP 31.38.01.14-Gen. - Piping classes DEP 31.38.01.23-Gen. - Piping classes developed primarily for use in the oil, multi-phase, water and gas pipeline systems from a wellhead to a plant facility administered primarily to the CSA Z662 standard.
Piping	Assembly of straight and bent pipes, fittings, flanges, gaskets, valves and other components (e.g., expansion joints, swivel joints, strainers, devices for mixing, separating, distributing, metering and flow control). It also includes pipe supporting elements and insulation. Piping does not include supporting structures (such as frames of buildings, stanchions or foundations) or equipment (e.g., heat exchangers, vessels, columns, pumps) or instrument impulse pipes. Instrument specifications apply downstream the last joint of the last process to instrument valve or valve assembly, defined for the instrument connection in the mechanical piping class. This can include the 5 mm restriction nipple where applicable.
Small bore	Piping components of size DN 50 (NPS 2) and below
spec break	Physical location as a single point dividing one piping class from another.
Very Toxic	Includes very toxic – acute / very toxic – chronic / very toxic – environment. For details, see DEP 01.00.01.30-Gen.

1.3.3 Specific definitions – Valves

Term	Definition
bellows	Flexible, thin-walled, circumferentially corrugated cylinder. It can have integral ends and can expand or contract axially under changing pressure.
fouling/ scaling/ service	Liquids or slurries, carrying suspended particles that can form a deposit on surfaces or build up in pockets within a valve. These can seriously impair the performance of valves unless the correct type is selected.
safety/relief valve	Pressure relief valve that is designed to relieve excessive pressure.
trunnion	Part of a ball valve which holds the ball on a fixed axis and which allows the ball to turn.

1.3.4 Abbreviations

Term	Definition
CAD	Computer Aided Design
DN	Diameter Nominal. The DN prefix indicates the nominal diameter of a piping system component in millimetres.
EJMA	Expansion Joint Manufacturers Association
NPS	Nominal Pipe Size. The NPS prefix indicates the nominal diameter of a piping system component in inches
PEFS	Process Engineering Flow Scheme

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (11).

1.5 SUMMARY OF MAIN CHANGES

Section/Clause	Change
All	DEP 31.38.01.11-Gen. "Piping – General Requirements" has been divided into three separate DEPs:
	DEP 31.38.01.24-Gen. - Piping – Engineering and Layout Requirements
	DEP 31.38.01.25-Gen. - Piping – Process Design Requirements
	DEP 31.38.01.26-Gen. - Piping – Pipe Stress Analysis Requirements
3.3.1.3, Item 2	Updated bullets in the SHALL [PS] statement. In the former DEP 31.38.01.11-Gen., this clause was 3.5.1.3, Item 3.
3.3.1.4, Item 1	Modified the final bullet of the SHALL [PS] statement. In the former DEP 31.38.01.11-Gen., this clause was 3.5.1.4, Item 1.
3.3.1.4, Item 4	Rephrased the SHALL [PS] statement. In the former DEP 31.38.01.11-Gen., this clause was 3.5.1.4, Item 4.
3.3.1.5, Item 4	Rephrased the SHALL [PS] statement. In the former DEP 31.38.01.11-Gen., this clause was 3.5.3.5, Item 4.
3.3.1.6, Item 1	Updated the SHALL [PS] statement. In the former DEP 31.38.01.11-Gen., this clause was 3.5.1.6, Item 1.
3.3.1.6, Item 2	Changed from 'shall' to SHALL [PS]. In the former DEP 31.38.01.11-Gen., this clause was 3.5.1.6, Item 2.
Appendix B	Rewrote the appendix. In the former DEP 31.38.01.11-Gen., this appendix was Appendix K.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. PIPE SIZING

1. Refer to DEP 31.38.01.25-Gen. for the requirements for completing the surge analyses.

3. PIPING BASICS

3.1 GENERAL

1. Refer to Part II of DEP 31.38.01.24-Gen. for piping requirements.
2. For additional requirements specific to offshore piping systems, refer to (Appendix D).
3. Span distances for support of straight pipe shall be per (Appendix A).
4. The effect of blast loads shall be evaluated for piping which is required to maintain the integrity in an explosion event.
 - a. Refer to DEP 37.01.10.11-Gen. for guidance on blast loadings.

3.2 PIPING LAYOUT REQUIREMENTS

1. Refer to Part III of DEP 31.38.01.24-Gen. for piping layout requirements.
2. Piping connected to more than one piece of equipment (e.g., a pump and its spare) shall be designed and supported in accordance with the following:
 - a. actual piping loads on equipment do not exceed the allowable loads/moments when one branch of the pipe is disconnected (e.g., during maintenance operations);
 - b. if multiple nozzles are applied (e.g., on air cooler banks) the connecting piping is designed so that small dimensional errors in construction can be accommodated;
 - c. the piping itself is adequately designed to compensate for any thermal expansion due to differential temperatures between operating equipment and stand-by equipment.

Intent is to design piping system to compensate for thermal expansion due to differential temperatures between (multiple) operating equipment and (multiple) stand-by equipment
3. All underground piping shall be designed to withstand the stresses due to soil settlement and thermal expansion of the piping.

3.3 PIPING STRESS ANALYSIS AND PIPE SUPPORTING

3.3.1 Piping stress analysis

3.3.1.1 General

1. Piping systems shall be routed, supported, anchored and guided so that stresses in the piping do not exceed those permitted by ASME B31.3 and so that loads on the connected equipment do not exceed the equipment design code for stresses arising from the following:
 - a. thermal expansion/contraction;
 - b. weight effects including the pipe contents, insulation and any other superimposed loads;
 - c. any other live loads superimposed when simultaneous occurrence is credible;
 - d. pressure effects;

- e. vibration or movements due to earthquakes or storms.

This is to prevent the following consequences:

- *failure of piping components due to overstress;*
- *leakage at joints;*
- *excessive loads and moments on connected equipment and pipe supports.*

2. Refer to DEP 31.38.01.29-Gen. for the requirements for pipe support design.

3.3.1.2 Local regulatory requirements

Local regulatory requirements of the country in which the plant will operate might have more stringent requirements than the codes and standards stated within this DEP. The pipe stress analysis is governed by the most stringent criterion.

3.3.1.3 Stress analysis critical line list

1. The computer program used for formal comprehensive stress analysis shall be a fully licensed product, recognised in the industry and approved by the Principal.
- a. If pipe stress calculations require the approval of national or local authorities, they shall be performed by methods approved by those authorities.

The purpose of the analysis is to calculate the thermal expansion/sustained or dynamic stresses, nozzle loads on the connected equipment and determine the type of pipe supports required.

2. The following lines SHALL [PS] be included on the critical line-list and investigated by the Contractor's pipe stress engineer (1.3.2) using formal comprehensive computer analysis:
- a. pipe size DN 80 to DN 200 (NPS 3 to NPS 8) with design temperature above 230 °C (450 °F);
 - b. pipe size DN 250 to DN 300 (NPS 10 to NPS 12) with design temperature above 175 °C (350 °F);
 - c. pipe size DN 350 to DN 450 (NPS 14 to NPS 18) with design temperature above 120 °C (250 °F);
 - d. pipe size DN 500 (NPS 20) and larger;
 - e. pipe size DN 80 and above (NPS 3 and above) connected to rotating equipment;
 - f. pipes of size DN 80 and above (NPS 3 and above) connected to air-cooled heat exchangers;
 - g. pipes of size DN 80 and above (NPS 3 and above) connected to pulsating equipment (reciprocating pumps or reciprocating compressors);
 - h. piping systems of size DN 80 (NPS 3) and larger where external movements, such as differential settlement of equipment and/or supports could cause unacceptable stresses or reaction forces;
 - i. all pipe sizes in cyclic service (regeneration/batch process) resulting in a stress range factor $f < 0.7$ per ASME B31.3 Fig. 302.3.5;
 - j. pipes of size DN 80 (NPS 3) and larger where engineered items are required like spring supports, expansion joints, snubbers;
 - k. piping systems of size DN 80 and above (NPS 3 and above) subjected to slug flow or water hammer;
 - l. piping systems of size DN 80 and above (NPS 3 and above) subjected to two-phase flow;

- m. pipes of size DN 80 (NPS 3) and above subjected to relief loads;
 - n. pipes of size DN 80 (NPS 3) and larger in very toxic (1.3.2) services with design temperatures above 200 °C (390 °F);
 - o. glass Reinforced Plastic piping systems sized DN 80 (NPS 3) and larger;
 - p. piping systems of size DN 80 (NPS 3) and larger subjected to steam out design and which are not classified as critical lines in accordance with (3.3.1.3, Item 2.a, 2.b, 2.c and 2.d);
 - q. jacketed piping systems of size DN 80 and above (NPS 3 and above);
 - r. piping systems of size DN 80 and above (NPS 3 and above) containing cryogenic fluid (below -100 °C (-150 °F));
 - s. pipes connected to Wellheads and X-mas trees;
 - t. piping systems of size DN 80 (NPS 3) and larger with hub clamp connectors or compact flanges;
 - u. pipes of size DN 80 (NPS 3) and larger along the derrick and the flare structure;
 - v. piping systems of size DN 80 (NPS 3) and larger associated with offshore platform bridges;
 - w. for all sizes of glass-lined pipe or piping connected to glass-lined equipment.
3. For the following piping systems, as a minimum, a formal simplified or approximate analysis (using manual methods) shall be performed:
- a. size DN 80 to DN 200 (NPS 3 to NPS 8) with design temperatures from 93 °C (200 °F) to 230 °C (450 °F);
 - b. size DN 250 (NPS 10) with design temperatures from 93 °C (200 °F) to 175 °C (350 °F);
 - c. size DN 300 (NPS 12) with design temperatures from 40 °C (100 °F) to 175 °C (350 °F);
 - d. size DN 350 to DN 400 (NPS 14 to NPS 16) with design temperatures from 40 °C (100 °F) to 120 °C (250 °F);
 - e. size DN 450 (NPS 18) with design temperatures from -18 °C (0 °F) to 120 °C (250 °F);
 - f. sizes DN 250 (NPS 10) and above with lower design temperature from minus 50 °C (minus 58 °F) to minus 100 °C (minus 148 °F).

The formal simplified or approximate analysis method includes analytical and chart methods that provide an evaluation of the forces, moments and stresses caused by displacement strains.

- 4. For existing piping systems, the applicable requirement from (3.3.1.3, Items 2 through 4) shall be applied if a change to the piping system leads to an increase in the pipe stresses.
- 5. All critical lines shall be identified as such on the project line-list.
- 6. The Contractor shall ensure the integrity and flexibility of lines that are not on the critical line list ("non-critical").

3.3.1.4 Piping stress analysis design basis

- 1. All critical piping systems identified through (3.3.1.3, Item 3) SHALL [PS] be checked for stresses caused by the following:
 - a. pressure (internal/external pressures);
 - b. weight effects of piping components and fluids;

- c. equipment vibration;
 - d. thermal expansion and contraction;
 - e. external loadings such as:
 - i. wind loads;
 - ii. seismic loads;
 - iii. settlement;
 - iv. frost heave;
 - v. snow loads;
 - f. stiffness changes;
 - g. enforced displacements;
 - h. shock loadings;
 - i. as limited by the nozzle loading requirements in Appendix D of DEP 31.38.01.24-Gen.
2. The Project line list shall form the basis of calculation for all the stresses.
3. All critical piping systems identified through (3.3.1.3, Item 3) shall be analysed for the detailed analysis conditions listed in Table 1.

Generally, most piping movements are due to thermal expansion, but the comprehensive stress analysis will address all of the conditions in Table 1.

Table 1 Detailed analysis conditions for critical piping systems

Pressure conditions	Temperature conditions	Other conditions	Occasional conditions								
Analyse the following cases: 1. Design Pressure 2. Maximum Operating Pressure 3. Operating Pressure 4. Cyclic pressure conditions	Analyse the following cases: 1. Design temperature 2. Lower design temperature 3. Maximum operating temperature 4. Operating temperature 5. Transient temperature conditions possibly caused by the following load cases: a. start-up and shut-down; b. protective steam heating or electrical heating including winterising; c. decoking; d. regeneration; e. compressor recycle; f. temperature drop by pressure relief, or depressurisation effect; <i>The specific pressure - temperature envelope can be defined as a specific load case to take credit for pressure reduction at low temperatures.</i> g. solar radiation; h. steam-out conditions.	1. Sustained loads analysed, e.g., weight of pipe and contents, insulation, fluid, valve and special items. 2. Thermal displacement of equipment nozzles calculated using the relevant piping temperature. 3. Effects of frictional resistance to thermal movement of the analyzed for all pipe sizes. a. Friction force calculated based on properties of the sliding surface and contact material. b. Following values used to select the static friction coefficient: <table><tr><th>Contact Surface</th><th>Friction Coefficient</th></tr><tr><td>Stainless Steel on PTFE</td><td>0.1</td></tr><tr><td>Steel on Steel</td><td>0.4</td></tr><tr><td>Steel on Concrete</td><td>0.6</td></tr></table> c. Code stress checks and actual piping forces and moments for equipment nozzles qualified with and without friction factor at pipe supports. 4. Stiffness changes: Stiffness changes analysed where applicable. 5. Barge accelerations, relative movement of platforms	Contact Surface	Friction Coefficient	Stainless Steel on PTFE	0.1	Steel on Steel	0.4	Steel on Concrete	0.6	1. Wind loads ¹ : analysed according to the applicable standard. a. Wind effects analysed by applying wind load in all four horizontal perpendicular directions which would induce maximum stress in the piping stress. 2. Seismic loads ² : a. in earthquake prone zones, earthquake loads are analysed to ensure structural integrity of pipe support structures; b. the frequency of earthquake occurrences, intensity and duration derived from seismic data or accelerograms (i.e., recordings of actual ground accelerations during earthquakes), local codes and standards or as specified by the Principal; c. for piping design with seismic loads, see (3.5); d. seismic effects analysed by applying seismic load in all four horizontal perpendicular directions which would induce maximum stress in the piping stress.
Contact Surface	Friction Coefficient										
Stainless Steel on PTFE	0.1										
Steel on Steel	0.4										
Steel on Concrete	0.6										