Introduction

DNV OS-F101 Submarine Pipeline Systems Code Compliance Program

December 1, 2011

Valid from program version 3.1
Developed by Pipeline Technology



Developed and marketed by
DET NORSKE VERITAS

DNV OS-F101 Submarine Pipeline Systems
Code compliance program

Related to the re-issue of the DNV Offshore Standard for Submarine Pipeline Systems, DNV has recently updated the program for doing the code check. ***You can also find some additional description about the program in the Excel sheet in "Read me" page.***

This program is programmed in Excel/Visual Basic.

The following code checks are included:

- Burst (pressure containment) related to both system test condition and operation,
- Collapse for an empty pipeline,
- propagating buckling for an empty pipeline,
- load controlled load interaction (moment, axial force and external/internal overpressure) and
- displacement controlled load interaction (axial strain and external/internal overpressure).

The program calculates

- the minimum required wall thickness for the given conditions and
- utilisation based on a wall thickness given by the user.

The program is made to fit engineering purposes, with one input and result sheet showing all necessary information given in short form. Explanations are given as regular Excel comments in relevant cells. The main sheet is meant to be used on the computer screen only. Print out on paper or copy it into a word document will foul it up its looks. Nevertheless it is shown in Figure 1 below to provide an impression of input and results. Note that the safety class and assumptions regarding corrosion and de-rated material can be selected individually for the different limit states/conditions.

When clicking the two calculation buttons on the main sheet, four report sheets are filled in:

- one for burst check, system test condition and operation,
- one covering system collapse and propagating buckling,
- one for load controlled load interaction, load cases a and b, and
- one for displacement controlled load interaction, load cases a and b.

These report sheets are meant for paper print-out and inclusion in reports. They contain all relevant input, some intermediate results (to ease external verification) and the results from the code check. These report sheets are shown in Figures 2 to 5.

The program allows the user to save and retrieve several sets of input data (cases) within one file, saving time and the amount of files required for each project.

The program also allows the user to perform parameter studies/sensitivity studies on each case. E.g. calculate minimum required wall thickness for varying depth as shown in Figure 6.

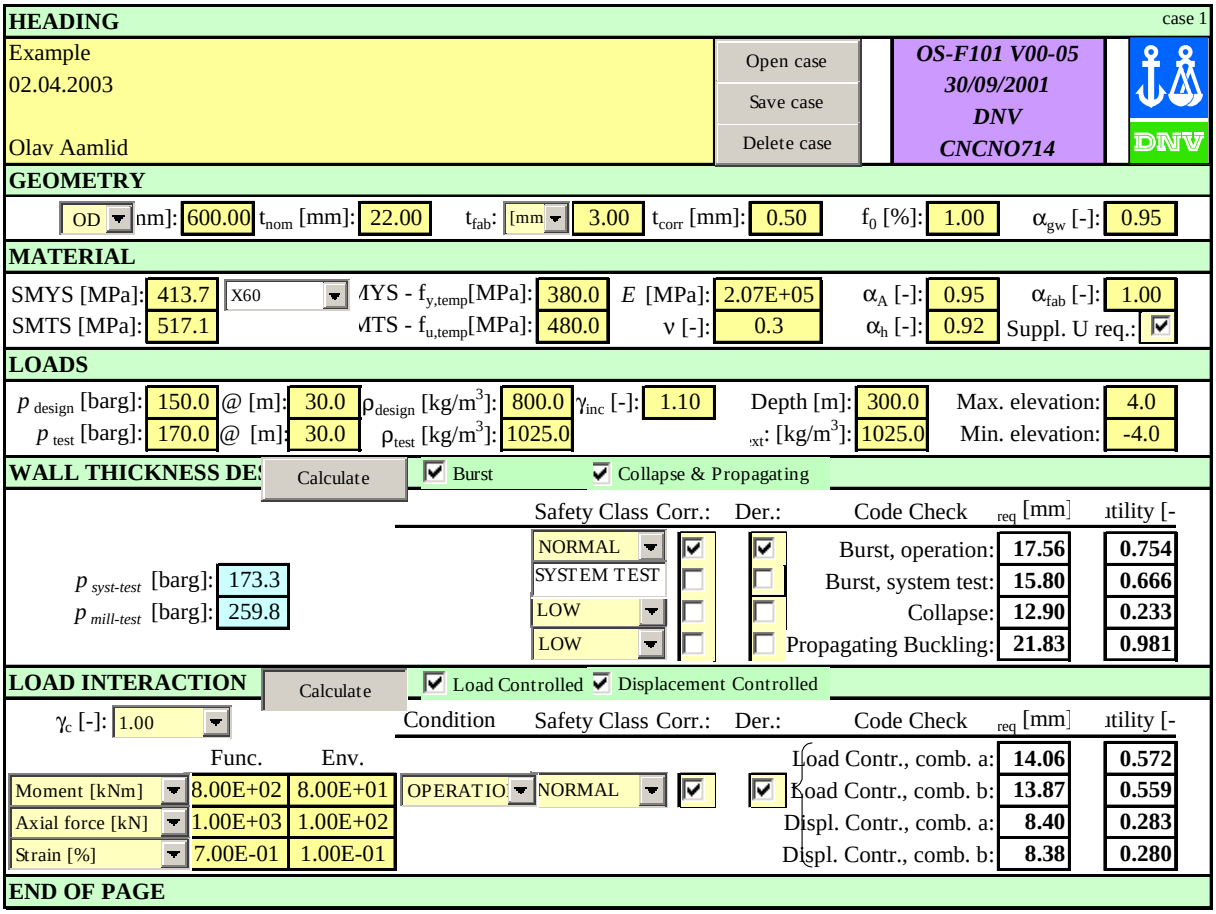


Figure 1: Main sheet with all input and results in short form.

	OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2000	**OS-F101 V00-05**
	Pressure Containment (bursting)	**30/09/2001**
DNV	**Developed by DNV OCT750**	***DNV CNCNO714***

Example
02.04.2003

Olav Aamlid

Date: Sign:	Date: Sign:
Prepared:	Verified:

RELEVANT INPUT PARAMETERS:		**Operation**	**System test**
Nominal outer steel diameter:	OD	600.00 mm	
Nominal steel wall thickness:	t_{nom}	22.00 mm	
Fabrication tolerance:	t_{fab}	3.00 mm	
Corrosion allowance:	t_{corr}	0.50 mm	
Specified minimum yield stress:	SMYS	413.7 MPa	
Specified minimum tensile strength:	SMTS	517.1 MPa	
Derating in yield stress due to temperature:	$f_{y,temp}$	33.7 MPa	
Derating tensile strength due to temperature:	$f_{u,temp}$	37.1 MPa	
Material strength factor:	α_U	1.00	1.00
Internal pressure at reference level:	$p_{int,ref}$	150.0 barg	170.0 barg
Reference level for internal pressure:	z_{ref}	30.0 m	30.0 m
Density of internal fluid:	ρ_{int}	800.0 kg/m3	1025.0 kg/m3
Incidental to design pressure ratio:	γ_{inc}	1.10	1.00
Depth:	d	296.0 m	296.0 m
Density of external fluid:	ρ_{ext}	1025.0 kg/m3	1025.0 kg/m3
Safety Class:		NORMAL	SYSTEM TEST
Corroded wall thickness:		YES	NO
Derated material properties:		YES	NO

INTERMEDIATE RESULTS:		**Operation**	**System test**
Characteristic yield stress:	f_y	380.00 MPa	413.70 MPa
Characteristic ultimate strength:	f_u	480.00 MPa	517.10 MPa
Steel wall thickness used in code check:	t_1/t_2	18.50 mm	19.00 mm
Pressure containment resistance, yielding limit state:	$p_{b,s}$	279.19 barg	312.44 barg
Pressure containment resistance, bursting limit state:	$p_{b,u}$	306.67 barg	339.59 barg
Pressure containment resistance, minimum of $p_{b,s}$ & $p_{b,u}$:	p_b	279.19 barg	312.44 barg
Material resistance factor:	γ_m	1.15	1.15
Safety class resistance factor:	γ_{SC}	1.138	1.046
Local design pressure:	p_{ld}	175.58 barg	202.78 barg
Local incidental pressure:	p_{li}	190.58 barg	202.78 barg
External pressure:	p_e	29.76 barg	29.76 barg
Pressure difference:	$p_{li} - p_e$	160.82 barg	173.02 barg

PRESSURE CONTAINMENT, BURSTING:	**Operation**	**System test**
Code check, utility:	**0.75 OK**	**0.67 OK**

Figure 2: Report sheet for burst checks.

	OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2000	**OS-F101 V00-05**
	System Collapse and Propagating Buckling	**30/09/2001**
DNV	**Developed by DNV OCT750**	***DNV CNCNO714***

Example
02.04.2003

Olav Aamlid

Date: Sign:	Date: Sign:
Prepared:	Verified:

RELEVANT INPUT PARAMETERS:		**Collapse**	**Prop. Buckling**
Nominal outer steel diameter:	OD	600.00 mm	
Nominal steel wall thickness:	t_{nom}	22.00 mm	
Corrosion allowance:	t_{corr}	0.50 mm	
Out-of-roundness:	f_0	1.00 %	
Young's modulus:	E	2.070E+05 MPa	
Poisson's ratio:	ν	0.30	
Specified minimum yield stress:	SMYS	413.7 MPa	
Derating in yield stress due to temperature:	$f_{y,temp}$	33.7 MPa	
Fabrication factor:	α_{fab}	1.00	
Material strength factor:	α_U	1.00	
Depth:	d	304.0 m	
Density of external fluid:	ρ_{ext}	1025.0 kg/m3	
Safety Class:		LOW	LOW
Corroded wall thickness:		NO	NO
Derated material properties:		NO	NO

INTERMEDIATE RESULTS:		**Collapse**	**Prop. Buckling**
Characteristic yield stress:	f_y	413.7 MPa	413.7 MPa
Steel wall thickness used in code check:	t_1/t_2	22.00 mm	22.00 mm
Elastic collapse pressure:	p_{el}	224.3 barg	NA
Plastic collapse pressure:	p_p	303.4 barg	NA
Characteristic collapse pressure:	p_c	172.7 barg	NA
Material resistance factor:	γ_m	1.15	1.15
Safety class resistance factor:	γ_{SC}	1.04	1.04
External pressure:	p_e	30.6 barg	30.6 barg

SYSTEM COLLAPSE AND PROPAGATING BUCKLING:	**Collapse**	**Prop. Buckling**
Code checks, utility:	**0.23 OK**	**0.98 OK**

Figure 3: Report sheet for system collapse and propagating buckling.

	OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2000	**OS-F101 V00-05**
	Load Interaction - Load Controlled	**30/09/2001**
DNV	**Developed by DNV OCT750**	***DNV CNCNO714***

Example
02.04.2003

Olav Aamlid

Date: Sign:	Date: Sign:
Prepared:	Verified:

RELEVANT INPUT PARAMETERS:			
Nominal outer steel diameter:	OD	600.00	mm
Nominal steel wall thickness:	t_{nom}	22.00	mm
Corrosion allowance:	t_{corr}	0.50	mm
Out-of-roundness:	f_0	1.00	%
Specified minimum yield stress:	SMYS	413.7	MPa
Specified minimum tensile strength:	SMTS	517.1	MPa
Derating in yield stress due to temperature:	$f_{y,temp}$	33.7	MPa
Derating tensile strength due to temperature:	$f_{u,temp}$	37.1	MPa
Young's modulus:	E	2.070E+05	MPa
Poisson's ratio:	ν	0.30	
Anisotropy factor:	α_A	0.95	
Material strength factor:	α_U	1.00	
Internal pressure at reference level:	$p_{int,ref}$	150.0	barg
Reference level for internal pressure:	z_{ref}	30.0	m
Density of internal fluid:	ρ_{int}	800.0	kg/m3
Depth:	d	300	m
Density of external fluid:	ρ_{ext}	1025.0	kg/m3
Load condition factor:	γ_C	1.00	
Functional bending moment:	M_F	800.0	kNm
Environmental bending moment:	M_E	80.0	kNm
Functional effective axial force:	S_F	1000.0	kN
Environmental effective axial force:	S_E	100.0	kN
Safety Class:		NORMAL	
Corroded wall thickness:		YES	
Derated material properties:		YES	

INTERMEDIATE RESULTS:		**Load comb. a**	**Load comb. b**
Internal pressure pressure:	$p_i = p_{ld}$	175.9 barg	
External pressure:	p_e	30.2 barg	
		internal overpressure	
Characteristic yield stress:	f_y	380.0 MPa	
Characteristic ultimate strength, circumferential:	f_u	480.0 MPa	
Characteristic ultimate strength, longitudinal:	f_u	456.0 MPa	
Steel wall thickness used in code check:	t_2	21.50 mm	
Design bending moment:	M_d	1016.0 kNm	984.0 kNm
Design effective axial force:	S_d	1270.0 kN	1230.0 kN
Design differential overpressure:	Δp_d	153.0 barg	153.0 barg
Plastic moment resistance:	M_p	2734.2 kNm	
Characteristic plastic axial force resistance:	S_p	14848.2 kN	
Pressure containment resistance, yielding limit state:	$p_{b,s}$	326.2 barg	
Pressure containment resistance, bursting limit state:	$p_{b,u}$	358.2 barg	
Pressure containment resistance, minimum of $p_{b,s}$ & $p_{b,u}$:	p_b	326.2 barg	
Hoop stress utilisation:	q_h	0.516	
	β	0.653	
Flow stress parameter:	α_c	1.131	
Material resistance factor:	γ_m	1.15	
Safety class resistance factor:	γ_{SC}	1.14	

LOAD INTERACTION - LOAD CONTROLLED	**Load comb. a**	**Load comb. b**
Code check:	**0.57 OK**	**0.56 OK**

Figure 4: Report sheet for load controlled load interaction.

	OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2000	**OS-F101 V00-05**
	Load Interaction - Displacement Controlled	**30/09/2001**
DNV	**Developed by DNV OCT750**	***DNV CNCNO714***

Example
02.04.2003

Olav Aamlid

Date: Sign:	Date: Sign:
Prepared:	Verified:

RELEVANT INPUT PARAMETERS:			
Nominal outer steel diameter:	OD	600.00	mm
Nominal steel wall thickness:	t_{nom}	22.00	mm
Corrosion allowance:	t_{corr}	0.50	mm
Out-of-roundness:	f_0	1.00	%
Girth weld factor:	α_{gw}	0.95	
Specified minimum yield stress:	SMYS	413.7	MPa
Derating in yield stress due to temperature:	$f_{v,temp}$	33.7	MPa
Young's modulus:	E	2.070E+05	MPa
Poisson's ratio:	ν	0.30	
Maximum yield to tensile ratio:	α_h	0.92	
Material strength factor:	α_U	1.00	
Internal pressure at reference level:	$p_{int,ref}$	150.0	barg
Reference level for internal pressure:	z_{ref}	30.0	m
Density of internal fluid:	ρ_{int}	800.0	kg/m3
Depth:	d	300.0	m
Density of external fluid:	ρ_{ext}	1025.0	kg/m3
Load condition factor:	γ_C	1.00	
Functional compressive strain:	ε_F	0.70	%
Environmental compressive strain:	ε_E	0.10	%
Safety Class:		NORMAL	
Corroded wall thickness:		YES	
Derated material properties:		YES	

INTERMEDIATE RESULTS:		**Load comb. a**	**Load comb. b**
Internal pressure:	$p_i = p_{ld}$	175.9 barg	
External pressure:	p_e	30.2 barg	
		internal overpressure	
Characteristic yield stress:	f_v	380.0 MPa	
Steel wall thickness used in code check:	t_2	21.50 mm	
Design compressive strain:	ε_d	0.91 %	0.90 %
Design differential overpressure:	Δp_d	153.0 barg	153.0 barg
Elastic collapse pressure:	p_{el}	209.3 barg	
Plastic collapse pressure:	p_p	272.3 barg	
Characteristic collapse pressure:	p_c	158.1 barg	
Hoop stress:	σ_h	205.9 MPa	
Plastic strain capacity.	ε_c	8.05 %	
Resistance strain factor:	γ_ε	2.50	
Material resistance factor:	γ_m	1.15	
Safety class resistance factor:	γ_{SC}	1.14	

LOAD INTERACTION - DISPLACEMENT CONTROLLED	**Load comb. a**	**Load comb. b**
Code check:	**0.28 OK**	**0.28 OK**

Figure 5: Report sheet for displacement controlled load interaction.

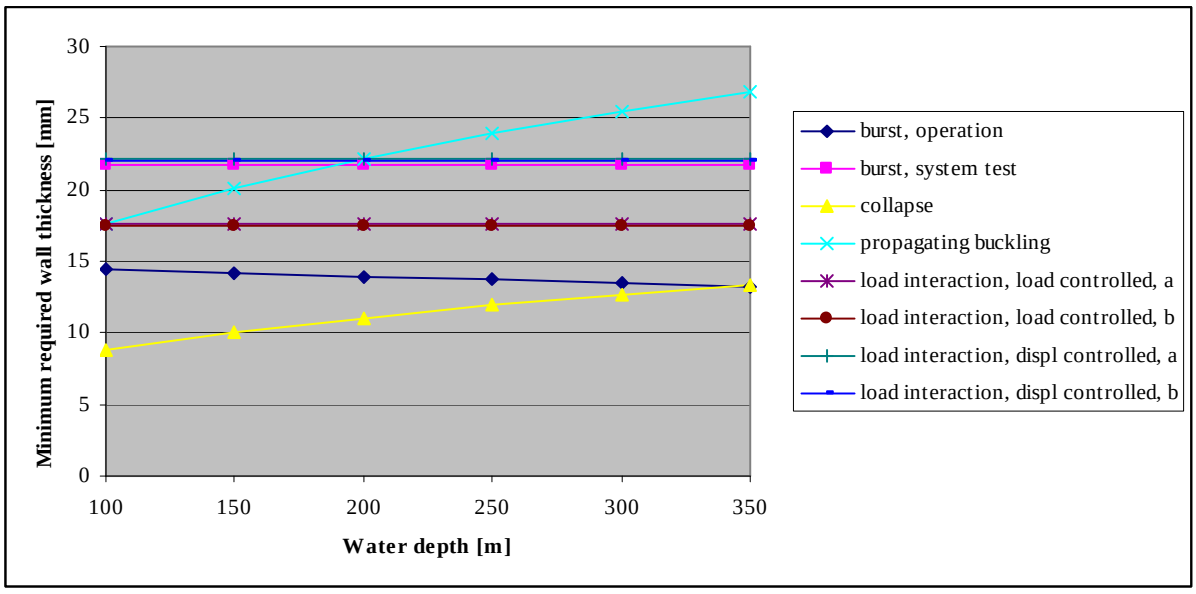


Figure 6: Plots of minimum required wall thickness versus water depth.

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