SESAM

USER MANUAL

DNV-OS-F101 Spreadsheet

CODE COMPLIANCE DESIGN OF SUBMARINE PIPELINES

DET NORSKE VERITAS

SESAM
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DNV-OS-F101 Spreadsheet
CODE COMPLIANCE DESIGN OF SUBMARINE PIPELINES

October 1, 2013

Valid from program version 3.2
Developed by Pipeline Technology

Developed and marketed by
DET NORSKE VERITAS

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DNV Software Report

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DNV-OS-F101 SPREADSHEET has been thoroughly validated and verified. However, no warranty, expressed or implied, is made by Det Norske Veritas, as to the accuracy or functionality of the program, and no responsibility is assumed in connection therewith.

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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 descriptions about the program in the Excel sheet in "Read me" page.***

1.1 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. It will not look good if printed out on paper or copied into a word document. Nevertheless it is shown below to provide an impression of input and results. The main sheet is adjusted to 100% zoom; other zoom values may lead to hidden text. 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 below.

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.

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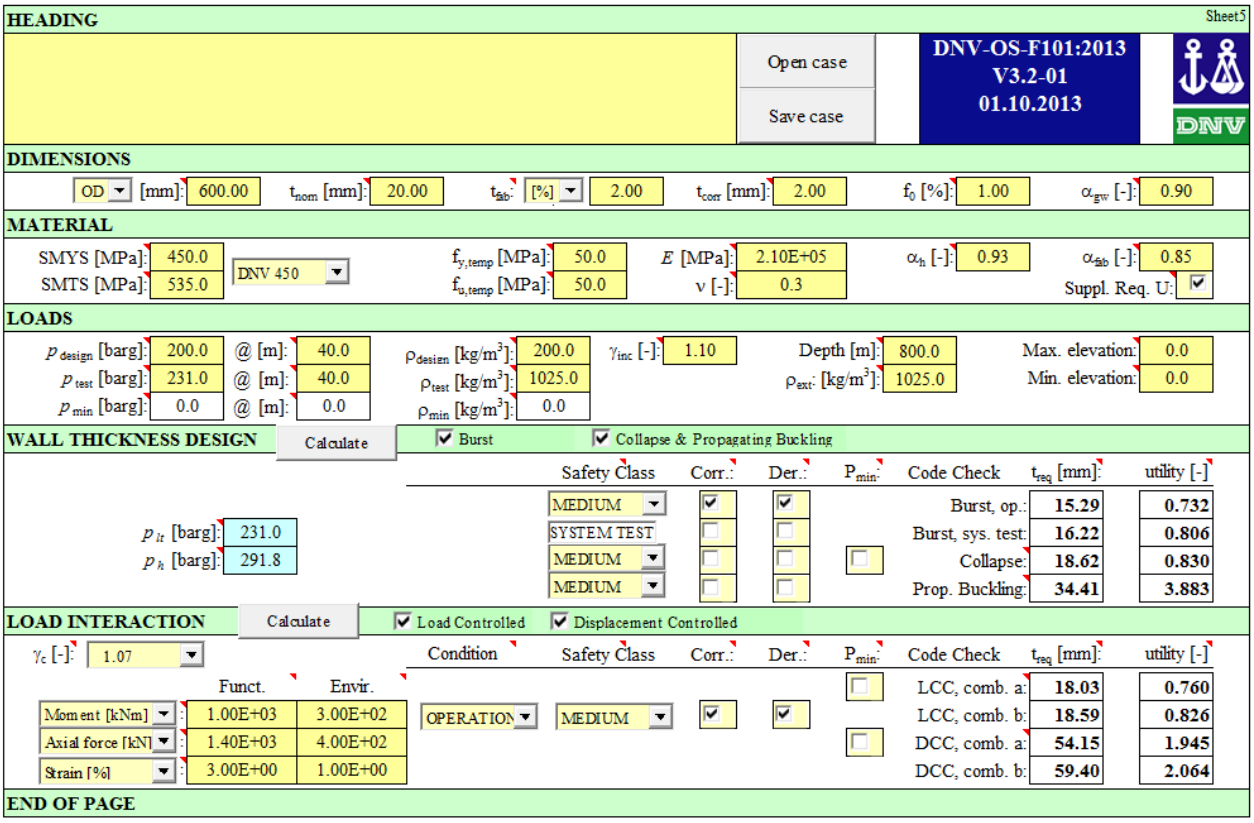


Figure 1 Main sheet with all input and key results

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OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2013 Pressure Containment (bursting) Developed by DNV TNTNO714	DNV-OS-F101:2013 V3.2-01 01.10.2013

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

RELEVANT INPUT PARAMETERS:		Operation	System test
Nominal outer steel diameter:	OD	600.00 mm	
Nominal steel wall thickness:	t_{nom}	20.00 mm	
Fabrication tolerance:	t_{fab}	2.00 %	
Corrosion allowance:	t_{corr}	2.00 mm	
Specified minimum yield stress:	SMYS	450.0 MPa	
Specified minimum tensile strength:	SMTS	535.0 MPa	
Derating in yield stress due to temperature:	$f_{y,temp}$	50.0 MPa	
Derating tensile strength due to temperature:	$f_{u,temp}$	50.0 MPa	
Material strength factor:	α_U	1.00	1.00
Internal pressure at reference level:	$p_{int,ref}$	200.0 barg	231.0 barg
Reference level for internal pressure:	z_{ref}	40.0 m	40.0 m
Density of internal fluid:	ρ_{int}	200.0 kg/m3	1025.0 kg/m3
Incidental to design pressure ratio:	γ_{inc}	1.10	1.00
Depth:	d	800.0 m	800.0 m
Density of external fluid:	ρ_{ext}	1025.0 kg/m3	1025.0 kg/m3
Safety Class:		MEDIUM	SYSTEM TEST
Corroded wall thickness:		YES	NO
Derated material properties:		YES	NO

INTERMEDIATE RESULTS:		Operation	System test
Characteristic yield stress:	f_y	400.00 MPa	450.00 MPa
Characteristic ultimate strength:	f_u	485.00 MPa	535.00 MPa
Steel wall thickness used in code check:	t_1/t_2	17.60 mm	19.60 mm
Pressure containment resistance, yielding limit state:	$p_{b,s}$	279.16 barg	350.95 barg
Pressure containment resistance, bursting limit state:	$p_{b,u}$	294.33 barg	362.81 barg
Pressure containment resistance, minimum of $p_{b,s}$ & $p_{b,u}$:	p_b	279.16 barg	350.95 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}	216.48 barg	315.46 barg
Local incidental/test pressure:	p_{lx}	236.48 barg	315.46 barg
External pressure:	p_e	80.44 barg	80.44 barg
Pressure difference:	$p_{lx} - p_e$	156.04 barg	235.02 barg

PRESSURE CONTAINMENT, BURSTING:	Operation	System test
Code check, utility:	0.73 OK	0.81 OK
Minimum required nominal wall thickness:	15.29 mm	16.22 mm

Figure 2 Report sheet for pressure containment

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OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2013	DNV-OS-F101:2013
System Collapse and Propagating Buckling	V3.2-01
Developed by DNV TNTNO714	01.10.2013

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

RELEVANT INPUT PARAMETERS:		Collapse	Prop. Buckling
Nominal outer steel diameter:	OD	600.00 mm	
Nominal steel wall thickness:	t_{nom}	20.00 mm	
Fabrication tolerance:	t_{fab}	2.00	
Corrosion allowance:	t_{corr}	2.00 mm	
Out-of-roundness:	f_0	1.00 %	
Young's modulus:	E	2.100E+05 MPa	
Poisson's ratio:	ν	0.30	
Specified minimum yield stress:	SMYS	450.0 MPa	
Derating in yield stress due to temperature:	$f_{y,temp}$	50.0 MPa	
Fabrication factor:	α_{fab}	0.85	
Material strength factor:	α_U	1.00	
Depth:	d	800.0 m	
Density of external fluid:	ρ_{ext}	1025.0 MEDIUM	
Safety Class:		MEDIUM	NO
Corroded wall thickness:		NO	NO
Derated material properties:		NO	NO
INTERMEDIATE RESULTS:		**450**	**450**
Characteristic yield stress:	f_y	19.6 MPa	20.0 MPa
Steel wall thickness used in code check:	t_1/t_2	160.89 mm	NA mm
Elastic collapse pressure:	p_{el}	249.9 barg	NA
Plastic collapse pressure:	p_p	127.1 barg	NA
Characteristic collapse pressure:	p_c	1.2 barg	1.2
Material resistance factor:	γ_m	1.14	1.14
Safety class resistance factor:	γ_{SC}	80.44	80.44
External pressure:	p_e	0.0 barg	80.4 barg
Minimum sustainable pressure:	p_{min}	0.0 barg	-
SYSTEM COLLAPSE AND PROPAGATING BUCKLING:		**0.829747536**	**3.88**
Code checks, utility:		**18.62 OK**	**34.41 NOT OK**
Minimum wall thickness:		18.62 mm	34.41 mm

Figure 3 Report sheet for collapse and propagating buckling

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OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2013	DNV-OS-F101:2013
Load Interaction - Load Controlled	V3.2-01
Developed by DNV TNTNO714	01.10.2013

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

RELEVANT INPUT PARAMETERS:			
Nominal outer steel diameter:	OD	600.00	mm
Nominal steel wall thickness:	t_{nom}	20.00	mm
Corrosion allowance:	t_{corr}	2.00	mm
Out-of-roundness:	f_0	1.00	%
Specified minimum yield stress:	SMYS	450.0	MPa
Specified minimum tensile strength:	SMTS	535.0	MPa
Derating in yield stress due to temperature:	$f_{y,temp}$	50.0	MPa
Derating tensile strength due to temperature:	$f_{u,temp}$	50.0	MPa
Young's modulus:	E	2.100E+05	MPa
Poisson's ratio:	v	0.30	
Material strength factor:	α_U	1.00	
Internal pressure at reference level:	$p_{int,ref}$	200.00	barg
Reference level for internal pressure:	z_{ref}	40.0	m
Density of internal fluid:	ρ_{int}	200.0	kg/m3
Depth:	d	800.0	m
Density of external fluid:	ρ_{ext}	1025	kg/m3
Load condition factor:	γ_C	1.070	
Functional bending moment:	M_F	1000.00	kNm
Environmental bending moment:	M_E	300.0	kNm
Functional effective axial force:	S_F	1400.0	kN
Environmental effective axial force:	S_E	400.0	kN
Safety Class:		MEDIUM	
Corroded wall thickness:		YES	
Derated material properties:		YES	

INTERMEDIATE RESULTS:		Load comb. a		Load comb. b	
Local internal pressure:	$p_i=p_{ld}/p_{lt}$	236.5	barg		
Local external pressure:	p_e	80.4	barg		
Local minimum sustainable pressure:	p_{min}	-	barg		
		internal overpressure			
Characteristic yield stress:	f_y	400.0	MPa		
Characteristic ultimate strength, circumferential:	f_u	485.0	MPa		
Characteristic ultimate strength, longitudinal:	f_u	485.0	MPa		
Steel wall thickness used in code check:	t_2	18.00	mm		
Design bending moment:	M_d	1494.0	kNm	1567.0	kNm
Design effective axial force:	S_d	2077.6	kN	2167.8	kN
Local net pressure:	$p_i - p_e$	156.0	barg	156.0	barg
Plastic moment resistance:	M_p	2438.8	kNm		
Characteristic plastic axial force resistance:	S_p	13164.5	kN		
Pressure containment resistance, yielding limit state:	$p_{b,s}$	285.7	barg		
Pressure containment resistance, bursting limit state:	$p_{b,u}$	301.2	barg		
Pressure containment resistance, minimum of $p_{b,s}$ & $p_{b,u}$:	p_b	285.7	barg		
Hoop stress utilisation:	q_h	0.631			
	β	0.296			
Flow stress parameter:	α_c	1.063			
Pressure factor:	α_p	0.704			
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:	0.76 OK	0.83 OK
Minimum wall thickness:	18.03 mm	18.59 mm

Figure 4 Report sheet for load controlled load combination

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OS-F101 - SUBMARINE PIPELINE SYSTEMS - 2013	DNV-OS-F101:2013
Load Interaction - Displacement Controlled	V3.2-01
Developed by DNV TNTNO714	01.10.2013

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

RELEVANT INPUT PARAMETERS:			
Nominal outer steel diameter:	OD	600.00	mm
Nominal steel wall thickness:	t_{nom}	20.00	mm
Corrosion allowance:	t_{corr}	2.00	mm
Out-of-roundness:	f_0	1.00	%
Girth weld factor:	α_{gw}	0.90	
Specified minimum yield stress:	SMYS	450.0	MPa
Derating in yield stress due to temperature:	$f_{y,temp}$	50.0	MPa
Young's modulus:	E	2.100E+05	MPa
Poisson's ratio:	ν	0.30	
Maximum yield to tensile ratio:	α_h	0.93	
Material strength factor:	α_U	1.00	
Internal pressure at reference level:	$p_{int,ref}$	200.0	barg
Reference level for internal pressure:	z_{ref}	40.0	m
Density of internal fluid:	ρ_{int}	200.0	kg/m3
Depth:	d	800.0	m
Density of external fluid:	ρ_{ext}	1025.0	kg/m3
Load condition factor:	γ_C	1.070	
Functional compressive strain:	ε_F	3.00	%
Environmental compressive strain:	ε_E	1.00	%
Safety Class:		MEDIUM	
Corroded wall thickness:		YES	
Derated material properties:		YES	

INTERMEDIATE RESULTS:		Load comb. a	Load comb. b
Local internal pressure:	$p_i=p_{ld}/p_{lt}$	216.5 barg	
Local external pressure:	p_e	80.4 barg	
Local minimum sustainable pressure:	p_{min}	- barg	
		internal overpressure	
Characteristic yield stress:	f_y	400.0 MPa	
Steel wall thickness used in code check:	t_2	18.00 mm	
Design compressive strain:	ε_d	4.55 %	4.83 %
Elastic collapse pressure:	p_{el}	124.6 barg	
Plastic collapse pressure:	p_p	204.0 barg	
Characteristic collapse pressure:	p_c	98.5 barg	
Plastic strain capacity.	ε_c	5.852 %	
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:	1.94 NOT OK	2.06 NOT OK
Minimum wall thickness:	54.15 mm	59.40 mm

Figure 5 Report sheet for displacement controlled load combination

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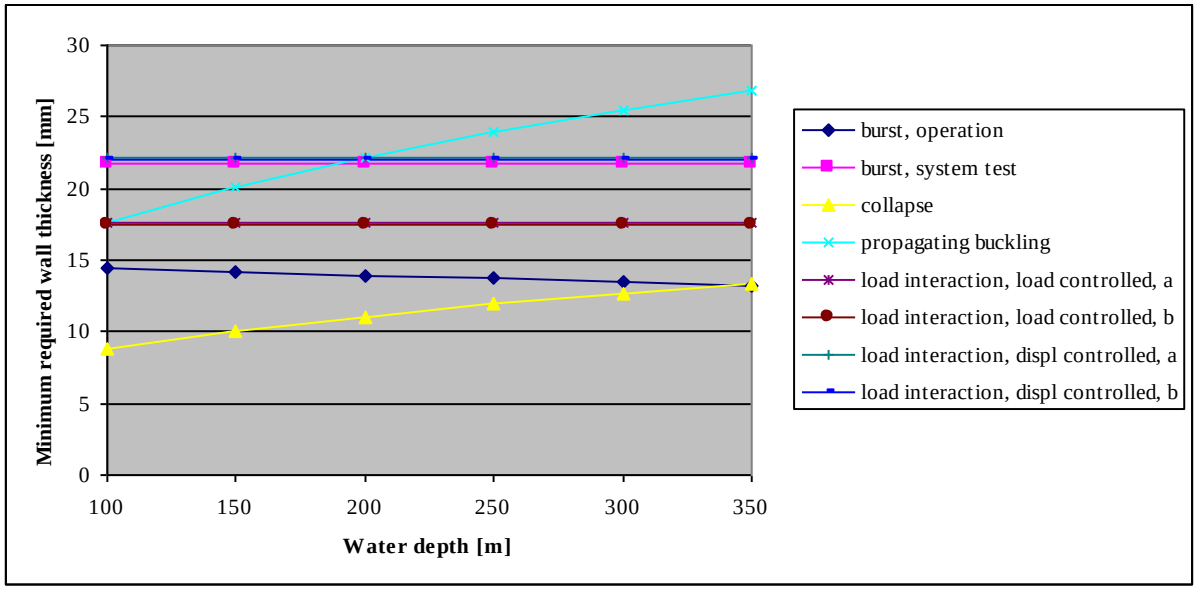


Figure 6 Plots of minimum required wall thickness versus water depth.

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