Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals

13 April 2021

Sub-Committee of Experts on the Transport of Dangerous Goods

Fifty-eighth session
Geneva, 28 June-2 July 2021
Item 6 (c) of the provisional agenda
Miscellaneous proposals for amendments to the Model Regulations on the Transport of Dangerous Goods: portable tanks

Inclusion of the new section 6.9.3 “Requirements for design, construction, inspection and testing of fibre reinforced plastic (FRP) valves, relief devices and manholes for portable tanks”

Submitted by the Russian Federation

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Environmental effects onto mechanical properties of FRP materials for valves, relief devices and manholes of portable tanks

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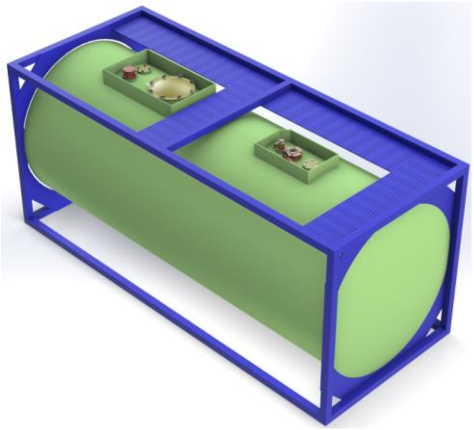
Why FRP?



Disadvantages of the steel valves, relief devices and manholes:
low corrosion resistance when exposed to aggressive substances

Advantages of the FRP valves, relief devices and manholes:
high strength-to-density ratio & corrosion resistance

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Why FRP?

FRP vs. steel equipment

	Manhole D500	Safety valve D80	Butterfly valve D80	Air line ball valve D32
FRP, kg	**6**	**3,6**	**3**	**1,4**
Typical steel, kg	17	7,1	6	2,9

Structural performance of the FRP equipment

Service temperature, ^{o}C	-60….+60
Maximum allowable working pressure, MPa	2,5
Attachment	Flanged / Coupling
Service fatigue life, cycles / years	6000 / 10
Hydraulic resistance	< 0,5

FRP examples

1000P	70% polyphenylene sulfide resin / 30% E-glass D 7-10 mm, L 50 mm / additives 10%	Injection molding
G	40% modified phenol-formaldehyde resin / 60% E-glass D 16 mm, L 50 mm	Press molding
DSV	70% polyphenylene sulfide resin / 30% E-glass D 7-10 mm, L 6 mm / additives 10%	Injection molding

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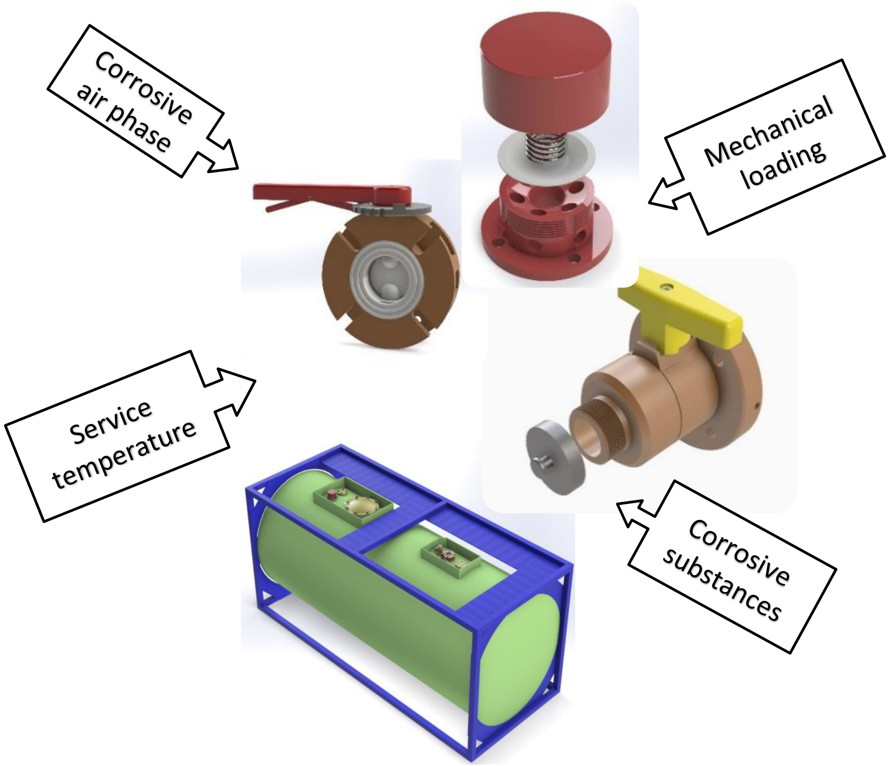
Environmental effects



Test program

#	Exposure	Mechanical tests
1	+20°C	ISO 527-4
2	+60°C	ISO 527-4
3	-60°C	ISO 527-4
4	+20°C, 168 hours of UV	ISO 527-4
5	+35°C / 168 hours of salt fog, ISO 12944-2, ISO 12944-6	ISO 527-4
6	+20°C, 168 hours of NaOH 40%(UN 1824), ISO 175	ISO 527-4
7	+20°C, 168 hours of H_2SO_4 95% (UN 1830), ISO 175	ISO 527-4
8	+20°C, 168 hours of HCl 37% (UN 1789), ISO 175	ISO 527-4
9	+20°C	ISO 13003, fatigue

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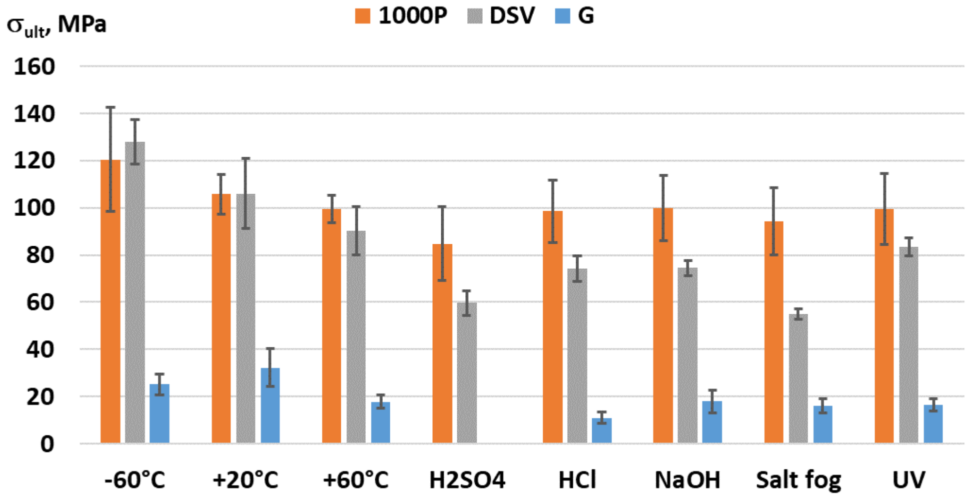
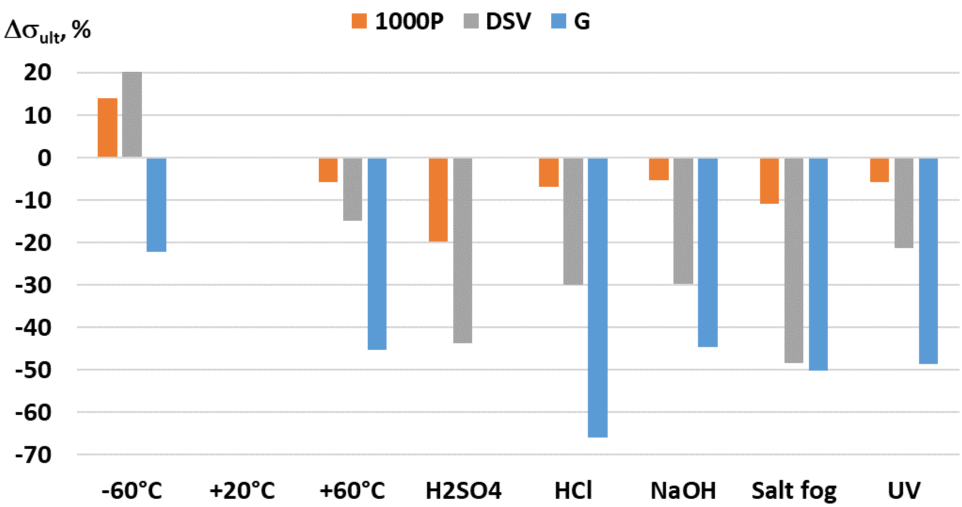
Tensile strength





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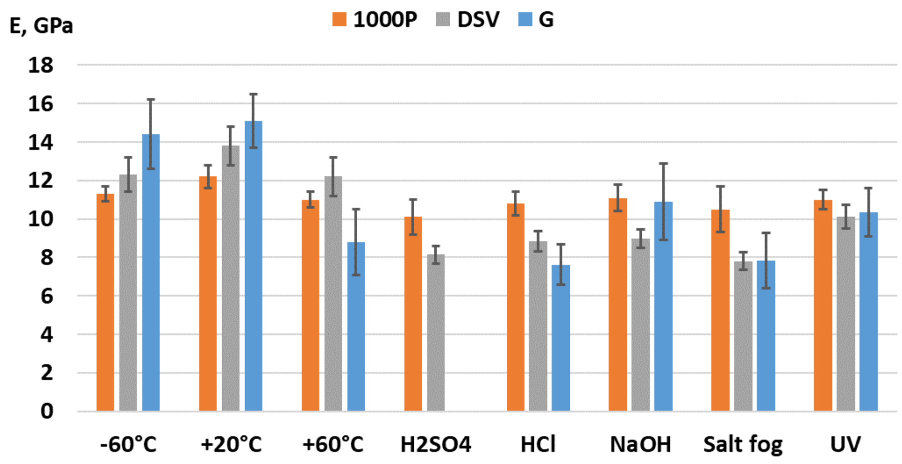
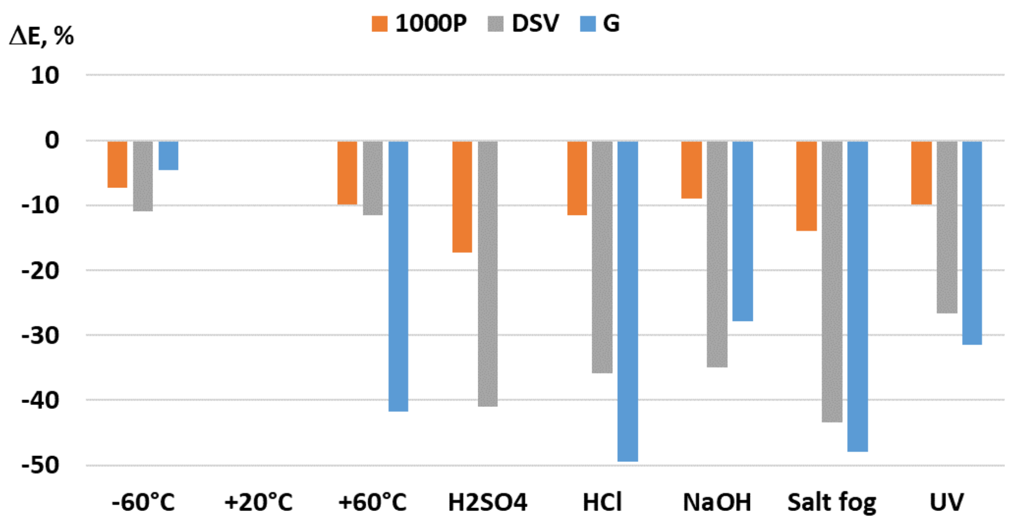
Elasticity modulus





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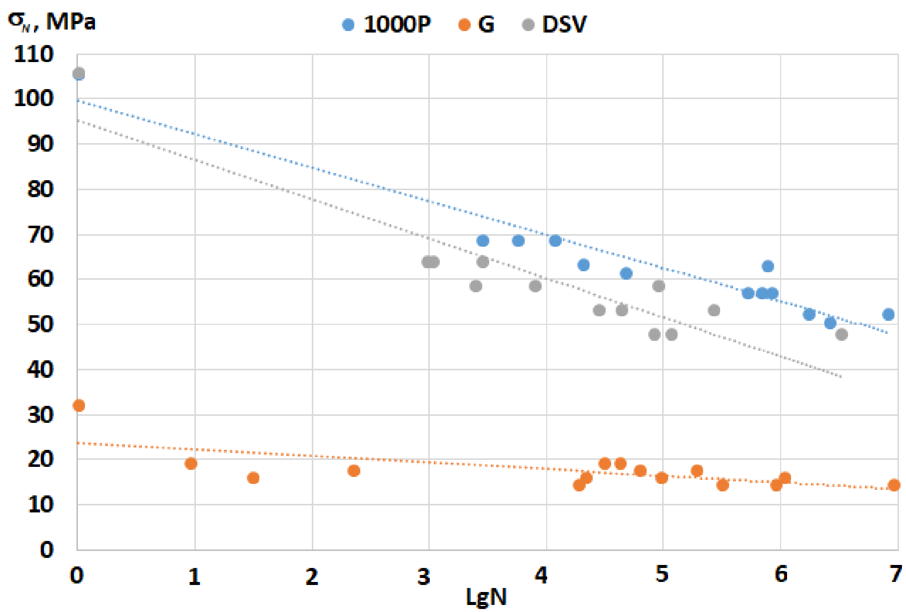
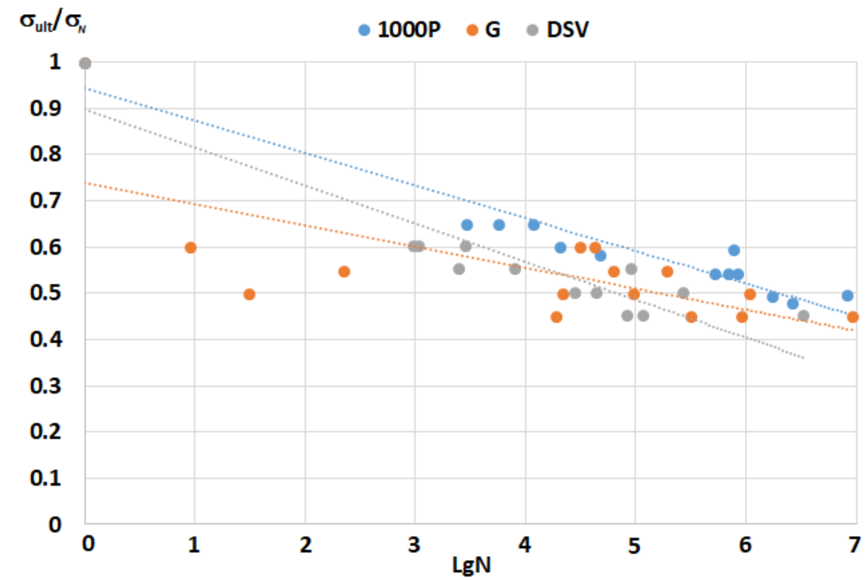
Fatigue





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Safety factor

$K = K_0 \times K_1 \times K_2 \times K_3 \times K_4 \times K_5$

K_0 is a strength factor = 1.5

K_1 is a factor related to the deterioration in the material properties due to effects of chemicals

K_2 is a factor related to the service temperature and the thermal properties

K_3 is a factor related to the fatigue of the material

K_4 is a factor related to the deterioration in the material properties due to effects of salt fog

K_5 is a factor related to the deterioration in the material properties due to effects of UV exposure

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Safety factor

$K = K_0 \times \boldsymbol{K_1} \times K_2 \times K_3 \times K_4 \times K_5$

K_1 is a factor related to the deterioration in the material properties due to effects of chemicals

$$K_1 = \frac{\sigma_n}{\sigma_{eff}}$$

σ_n – nominal tensile strength

σ_{eff} – tensile strength after chemical exposure

$\sigma_{eff} = \min\left(\sigma_{eff}^1, \sigma_{eff}^2 \ldots\ldots \sigma_{eff}^k\right)$, *1,2….k* – substance identifiers

	1000P	G	DSV
H_2SO_4	1.25	Dissolution	1.78
HCl	1.07	2.94	1.43
NaOH	1.06	1.80	1.42
$\boldsymbol{K_1}$	**1.25**	**∞**	**1.78**

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Safety factor

$K = K_0 \times K_1 \times \boldsymbol{K_2} \times K_3 \times K_4 \times K_5$

K_2 is a factor related to the service temperature and the thermal properties

$$K_2 = \frac{\sigma_n}{\sigma_{temp}}$$

σ_n – nominal tensile strength

σ_{temp} – tensile strength under working temperature

$\sigma_{temp} = \min\left(\sigma_{temp}^1, \sigma_{temp}^2 \ldots\ldots \sigma_{temp}^k\right)$, *1,2….k*– temperature identifiers

	1000P	**G**	**DSV**
- 60^{0}C	0.88	1.29	0.83
+ 60^{0}C	1.06	1.82	1.18
$\boldsymbol{K_2}$	**1.06**	**1.82**	**1.18**

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Safety factor

$K = K_0 \times K_1 \times K_2 \times \boldsymbol{K_3} \times K_4 \times K_5$

K_3 is a factor related to the fatigue of the material

$$K_3 = \frac{\sigma_n}{\sigma_N}$$

σ_n – nominal tensile strength

σ_N – failure stresses for a given number of loading cycles

	1000P	**G**	**DSV**
$\boldsymbol{\sigma_n}$	105.7	32.3	106
$\boldsymbol{\sigma_{N=10000}}$	68.7	17.8	58.3
$\boldsymbol{K_3}$	**1.54**	**1.82**	**1.82**

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Safety factor

$K = K_0 \times K_1 \times K_2 \times K_3 \times \boldsymbol{K_4} \times K_5$

K_4 is a factor related to the deterioration in the material properties due to effects of salt fog

$$K_4 = \frac{\sigma_n}{\sigma_{sf}}$$

σ_n – nominal tensile strength

σ_{sf} – tensile strength after salt fog exposure

	1000P	**G**	**DSV**
$\boldsymbol{\sigma_n}$	105.7	32.3	106
$\boldsymbol{\sigma_{sf}}$	94.3	16.1	54.8
$\boldsymbol{K_4}$	**1.12**	**2.01**	**1.93**

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Safety factor

$K = K_0 \times K_1 \times K_2 \times K_3 \times K_4 \times \boldsymbol{K_5}$

K_5 is a factor related to the deterioration in the material properties due to effects of UV exposure

$$K_5 = \frac{\sigma_n}{\sigma_{UV}}$$

σ_n – nominal tensile strength

σ_{UV} – tensile strength after UV exposure

	1000P	**G**	**DSV**
$\boldsymbol{\sigma_n}$	105.7	32.3	106
σ_{UV}	99.5	16.6	83.5
$\boldsymbol{K_5}$	**1.06**	**1.95**	**1.27**

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Safety factor

$$K = K_0 \times K_1 \times K_2 \times K_3 \times K_4 \times K_5$$

	1000P	G	DSV
K_0	1.5	1.5	1.5
K_1	1.25	∞	1.78
K_2	1.06	1.82	1.18
K_3	1.54	1.82	1.82
K_4	1.12	2.01	1.93
K_5	1.06	1.95	1.27
K	**3.64**	**∞**	**13.97**

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Thank you for your time!

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