Packages for liquids – Internal Pressure Test

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Abstract

The basic requirements for transport of dangerous gods are that a packaging shall be able to withstand certain mechanical and chemical stresses, as stated in SRVFS 2006:7. The requirements shall guarantee a reasonable level of protection for both humans and environment and is intended to create a system taking into account different types of substances and packaging. Principles for classification, packing requirements, testing procedures shall be simple and clear and guarantee that a minimum level of safety can be achieved without advanced technical equipment and expertise. No requirements concerning test temperatures are given in the regulations but in the standard SS-EN-ISO 16104:2003 “Packaging – Transport packaging for dangerous goods – Test Methods” the internal hydraulic pressure test, for plastics drums, jerricans and composite packaging, shall be performed at a temperature of +12 °C, otherwise the internal test pressure shall be adjusted with a pressurization factor corresponding to the temperatures used in the test. At temperatures below +12 +/- 2 °C the test pressure is increased and if the temperature is higher the pressure is lowered. Correction factors exist from +2 °C to +20 °C, and for all temperatures above +20 °C the correction factor is the same as for +20 °C. Neither ADR, IMDG-code, ICAO-TI or the UN-recommendations recommend any test temperature.

The aim with this project was to perform internal pressure test at different water temperatures. Three jerricans of each type were tested at the following temperatures: +3, +20, +40 and +55 °C.

As can be seen in the test results the burst pressure decreases substantially with rising temperature. For jerrican A the burst pressure is reduced from 234 kPa at +3 °C to 175 kPa at +20 °C, 151 kPa at 40 °C and 114 kPa at +55 °C. At +55 °C the burst pressure is reduced to less than half what it was at +3 °C. Jerrican B is also reduced from 545 kPA at +3 °C to 226 kPa at +55 °C while jerrican C is only reduced from 185 kPa to 136 kPa in the same temperature interval.

The gradient of the correction factor in table 3 in EN ISO 16104:2003 correspond very well with gradient of the tested jerricans in the temperature span between +2 °C and +20 °C.

All jerricans were made of PE. The pressure/temperature curves show a linear gradient but indicates that the gradient can differ between different materials. Jerrican A and B are produced by the same manufacturer in the same material and show corresponding behaviour, also corresponding to the correction factors in the standard. Jerrican C is produced by another manufacturer and does not show such significant reduction of burst pressure at higher temperatures.

Key words: Packaging, jerricans, transport, dangerous goods, internal pressure test

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1 Introduction

The basic requirements for transport of dangerous gods are that a packaging shall be able to withstand certain mechanical and chemical stresses, as stated in SRVFS 2006:7. The requirements shall guarantee a reasonable level of protection for both humans and environment and is intended to create a system taking into account different types of substances and packaging. Principles for classification, packing requirements, testing procedures shall be simple and clear and guarantee that a minimum level of safety can be achieved without advanced technical equipment and expertise. No requirements concerning test temperatures are given in the regulations but in the standard SS-EN-ISO 16104:2003 “Packaging – Transport packaging for dangerous goods – Test Methods” the internal hydraulic pressure test, for plastics drums, jerricans and composite packaging, shall be performed at a temperature of +12 °C, otherwise the internal test pressure shall be adjusted with a pressurization factor corresponding to the temperature used in the test. At temperatures below +12 +/- 2 °C the test pressure is increased and if the temperature is higher the pressure is lowered. Correction factors exist from +2 °C to +20 °C.

Neither ADR, IMDG-code, ICAO-TI or the UN-recommendations recommend any test temperature.

The lowest hydraulic gauge pressure shall, according to § 6.1.5.5.4 in the ADR, be applied and determined by one of the following methods:

a) not less than the total gauge pressure measured in the packaging (i.e the vapour pressure of the filling liquid and the partial pressure of the air or other inert gases, minus 100 kPa) at +55 °C, multiplied by a safety factor of 1.5; this total gauge pressure shall be determined on the basis of a maximum degree of filling in accordance with UN Recommendation Part 4.1.1.4 and a filling temperature of +15 °C.

b) not less than 1.75 times the vapour pressure at +50 °C of the liquid to be transported, minus 100 kPa but with a minimum test pressure 100 kPa.

c) not less than 1.5 times the vapour pressure at +55 °C of the liquid to be transported, minus 100 kPa but with a minimum test pressure of 100 kPa.

For packaging for transport of packing group I liquid, the minimum test pressure is 250 kPa.

The aim with this project was to perform internal burst pressure test at different water temperatures. The tests were performed at following temperatures: +3, +20, +40 and +55 °C.

The results from the tests were also compared to the correction factors given in SS-EN-ISO 16104:2003 “Packaging – Transport packaging for dangerous goods – Test Methods” table 3.

2 Test objects

Three different types of PE jerricans, from two manufacturers, were bought on the open market. All had a volume of 5 litres and were produced of PE (polyethylene). Jerrican A and B were manufactured with the same material composition while jerrican C was manufactured by another manufacturer, using another material. The jerricans are described in following table:

	Manufacturer	**Marking**	**Colour**
A	Emballator Melleruds Plast AB H5L/40 265 g, BL 1481	UN 3H1/Y1.4/100/07/S/SP-116805	White
B	Emballator Melleruds Plast AB H5L/40 380 g, BL 1481	UN 3H1/Y1.4/100/07/S/SP-116805	White
C	Petrolia, Söderfors, HDPE 5802	02 PE 03	Grey

3 Test method

The tests were performed in a cabinet in which the temperature was kept constant at desired level. The jerricans were filled with water of the same temperature as in the cabinet. The internal water pressure was increased inside the jerrican until burst. The flow of water needed to keep the pressure rate constant was of the same temperature as in the cabinet. The pressure inside the jerricans was at test start set to 50 kPa and after that the pressure was increased until rupture at a rate of 2 kPa per minute.

4 Results

4.1 Test results in tables

4.1.1 Jerrican Type A

SP marking	Mass g	Temperature °C	Burst Pressure kPa	Mean Value kPa	Rupture orientation
A3a	269.15	3	239		Weld-line
A3b	268.46	3	227		Weld-line
A3c	268.25	3	236		Weld-line
				234	
A20a	268.72	20	172		Weld-line
A20b	269.00	20	188		Weld-line
A20c	268.12	20	165		Weld-line
				175	
A40a	268.65	40	(200)		Ductile
A40b	269.03	40	141		Weld-line
A40c	269.43	40	160		Weld-line
				151	
A55a	268.35	55	106		Weld-line
A55b	268.08	55	116		Weld-line
A55c	269.29	55	120		Weld-line
				114	

Remark: Values within brackets are not used in the mean value calculation.

4.1.2 Jerrican Type B

SP marking	Mass g	Temperature °C	Burst Pressure kPa	Mean Value kPa	Rupture orientation
B3a	398.12	3	548		Weld-line
B3b	397.14	3	541		Weld-line
B3c	397.26	3	(>511)		Leakage in cap
				545	
B20a	395.83	20	419		Weld-line
B20b	392.30	20	412		Ductile
B20c	394.84	20	418		Ductile
				416	
B40a	397.44	40	306		Weld-line
B40b	398.91	40	317		Ductile
B40c	395.74	40	308		Weld-line
				310	
B55a	399.36	55	266		Ductile
B55b	398.62	55	258		Ductile
B55c	394.44	55	273		Weld-line
				266	

Remark: Values within brackets are not used in the mean value calculation.

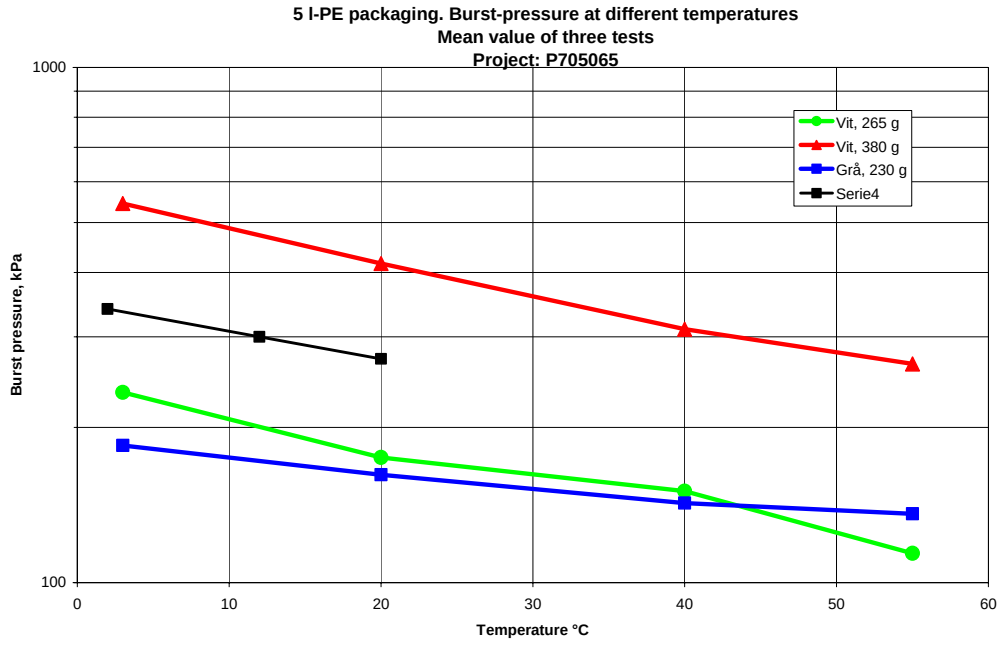
4.1.3 Jerrican Type C

SP marking	Mass g	Temperature °C	Burst Pressure kPa	Mean Value kPa	Rupture orientation
C3a	232.83	3	193		Weld-line
C3b	233.08	3	181		Weld-line
C3c	230.72	3	180		Weld-line
				185	
C20a	233.60	20	161		Weld-line
C20b	231.79	20	167		Weld-line
C20c	232.16	20	158		Weld-line
				162	
C40a	231.86	40	139		Weld-line
C40b	231.38	40	152		Weld-line
C40c	231.90	40	137		Weld-line
				143	
C55a	233.56	55	139		Weld-line
C55b	232.33	55	138		Ductile
C55c	233.23	55	131		Ductile
				136	

4.2 Results in diagram

The relationship between burst pressure and temperature, for the tested samples, is shown in diagram 1. In the same diagram is shown, as serie 4, correction values from the EN ISO standard for a jerrican with a fictive test pressure of 300 kPa at +12 °C.

Diagram 1



5 Summary and conclusion

As can be seen in the test results the burst pressure decreases substantially with rising temperature. For jerrican A the burst pressure is reduced from 234 kPa at +3 °C to 175 kPa at +20 °C, 151 kPa at 40 °C and 114 kPa at +55 °C. At +55 °C the burst pressure is reduced to less than half what it was at +3 °C. Jerrican B is reduced from 545 kPa at +3 °C to 226 kPa at +55 °C while jerrican C is only reduced from 185 kPa to 136 kPa in the same temperature interval.

The gradient of the correction factor in table 3 in EN ISO 16104:2003 corresponds very well to gradients of the tested jerricans in the temperature span between +2 °C and +20 °C, see diagram 1.

All jerricans show a linear gradient but the curves indicate that the gradient can vary between different materials. Jerrican A and B are manufactured in the same material by the same producer and show corresponding behaviour, also corresponding to the correction factors in the standard. Jerrican C is manufactured by another producer in a different material and does not show such significant reduction of burst pressure at higher temperatures.

The results show that the temperature has a great influence on the burst pressure of jerricans produced in PE. It should be considered that a jerrican tested at a temperature within the span +3 - +20 °C can have a reduction of its ability to withstand internal pressure with more than half of the burst pressure if tested at +3 °C or a third if tested at 20 °C during a transport at +55 °C.

Temperatures of +55°C are not unusual in covered vehicles during summertime in Sweden and in other parts of the world the temperatures can rice to much higher values. It is interesting to notice that the vapour pressure at high temperatures are taken in to consideration but the decrease in strength of PE containers (jerricans) at those temperatures are not clarified.

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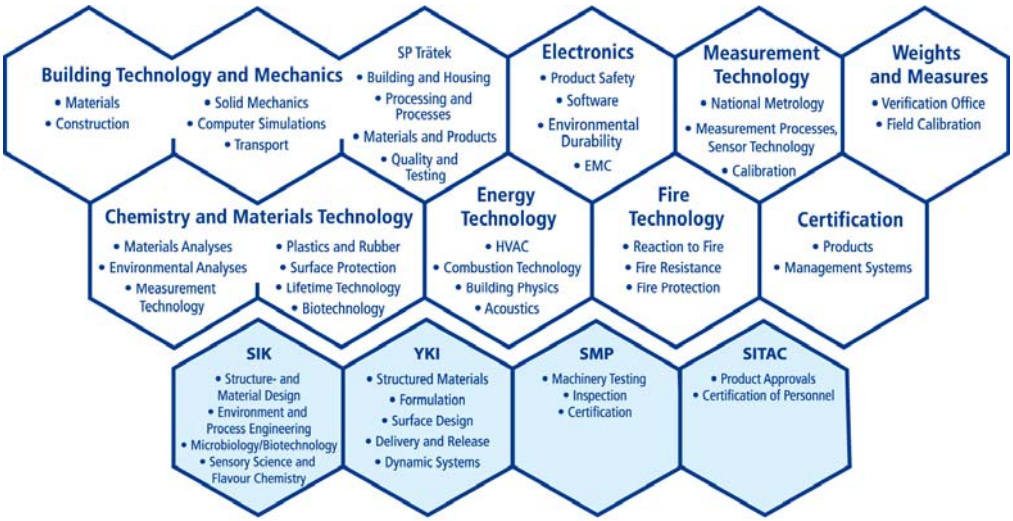

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