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Flexible bulk container (FBC) design, testing and use
Photographs of secured and unsecured FBCs in marine vessel holds

Transmitted by the International Dangerous Goods and Containers Association (IDGCA)

1. Design

FBC manufactured in Russia by CJSC New Technology in Transportation (MK-14-10) are designed for transportation and temporary storage of bulk dangerous goods, packaging group III with the safety factor of 8:1.

FBC may be used for transportation both of hydrophobic and non-hydrophobic bulk dangerous goods, as well as nonhazardous goods.

FBC are containers for multimodal transportation, they are transported by railway, motor and waterborne (marine and river) cargo transport. FBC are used for repeated transportation of bulk solids in mass and industrial volumes.

FBCs operating capability is dependant on the container design and durability of materials they are made of.

FBC container consists of a carcass grid with a handling device (slings) in its upper part and the bottom part is equipped with a locking device, and the container body with service equipment (loading and unloading arms). The unloading arm is also equipped with a locking device. The carcass grid is connected to the container body in the upper part with the help of a clasp joint. The discharge arm is locked in the central hole of the carcass grid bottom with a clasp joint.

The carcass grid is the bearing element of a container and provides for its safe operation. The carcass grid ensures cylindrical (not barrel-contoured) form of the container. The container body provides for goods integrity preventing its spillage and soaking. The loading arm is closed by tying with a strong strap and is sealed. The unloading arm is shut with two locking devices protected from self-opening, one of which is located at the unloading arm of the body, and the second one is on the protective valves of the central carcass grid bottom hole.

The carcass grid is made of a 50mm strap with the tearing strength of at least 2500kg. The strap is manufactured at weaving looms of polyester threads. The strap maintains its strength under the temperature from 50°C below zero to 120°C above zero; it resists 50% acid and 20% alkaline.

The carcass grid is made by sewing straps together in a strong, continuous, symmetrical structure where sewing joints and straps are equal in strength. The carcass grid has a protective waterproof cloth bottom preventing bottom insert from accidental punctures.

The container body is made of polyether fabric with double-sided rubber coating. The waterproof cloth is vulcanized and is characterized by the tearing core threads strength of over 500kg/50mm, and the tearing shoot strength of over 250kg/50mm. The waterproof cloth remains strong and waterproof during the entire life cycle under the temperature from 50°C below zero to 100°C above zero; it resists 50% acid and 50% alkaline. The cloth is also resistant to UV light, ozone, high cycling temperatures from 10°C to 100°C and substances transported.

The waterproof cloth density is 0.95 kg/m^2.

All FBC parts are sewed with a double zigzag seam using industrial-type sewing machines, e.g. Adler-166 and Adler-98 or similar. All seams are glued with a special waterproof strap. The FBC cloth and seams are made waterproof and are capable of withstanding the pressure of 25kPa.

The loading and unloading arms of the container body are shut by tight folding and bundling. As it has been already mentioned above, the unloading arm is preliminary shut off by the first locking device and after folding and latching it is packed under the protective valves that are locked with the second locking device. The length of tightly folded arm and goods load affecting it facilitate waterproofing of this part of the container body.

FBC dimensions have been determined by reference to railway car dimensions. The internal dimensions of open railway cars are 12.5-13.5m long and 2.8m wide. Specialized open railway cars 19.7m long are manufactured as well. The railway car length provides for holding of 5 and 8 FBCs with the diameter of 2.45m with small gaps between each FBC and car end walls. At the same time edgewise there is a gap of 0.15-0.17m between FBC and car side walls. Such an FBC diameter is acceptable and at the same time maximum allowable for truck body transportation of FBCs. In order to provide for the maximum FBC stability, its height shall be approximately equal to the diameter. For FBC MK-14-10 the height is 2.6m. Herewith such FBCs have the loaded volume of 12m^3.

FBC capacity and correspondingly its freightage predetermine environmental and economic feasibility of bulk dangerous goods transportation. Thus, for instance FBC are used for transportation of various materials, with their bulk weight being 600-2500 kg/m3. Herewith railway car capacity is used to the full in case they are exploited for transportation of FBC filled with goods the bulk weight of which is over 1000 kg/m3. However, the weight of completely filled FBC for transportation of goods with the bulk weight significantly less than 1000 kg/m3 is unfeasibly small as compared to the established FBC capacity leading to incomplete railway car loading and consequently to economic losses.

In this context increase in FBC volume with preservation of their capacity is an acute issue. Solution of this issue will facilitate reduction of empty car runs, increase in cargo traffic and decrease of the time required for dangerous goods transportation including their utilization. Moreover increase in FBC volume facilitates reduction of vessel downtime during FBC loading and unloading, and compact FBC stockpiling in the port and on berth.

For this reason FBC have the volumes 3-13 m3 for dry solids, packing group III.

In this case FBC freightage is limited to 14000kg with reference to the open railway car capacity of 70000kg.

Use of FBC solves both environmental and economic problems as it eliminates the need of expensive utilization of disposable IBC containers (primarily with the capacity of 1000kg) that are disposed of after each shipment of dangerous goods. Herewith FBC provides for multimodal transportation of dangerous goods without spills and soaking in hard climatic conditions. FBC service life is 5-6 years.

The total container weight does not exceed 70kg. The carcass grid and container body weight is 30 and 40kg, respectively. Tightly folded FBC has the volume of 0.35m^3.

2. Testing

In the process of designing and manufacturing Russian FBCs are subjected to acceptance tests, periodic tests and structure type tests. During operation Russian FBCs are subjected to periodic inspection.

During acceptance tests all FBCs are checked for compliance with the drawings by measuring their geometrical dimensions, weight, and visual inspection of seams and their gluing.

During periodic tests held once every three years 3 FBCs are taken from the finished product storage and are checked for compliance with the waterproofing criterion specified in the technical documents.

Type tests are performed in case of any changes in the structure, manufacturing process adjustment and use of new materials, but at least once every 4.5 years. For this end, 3 FBCs are taken from the finished product storage and are tested for compliance with the strength parameters set forth in the technical documents. Such tests are specified in UN/SCETDG/35/INF.27/Add.1 and UN/SCETDG/35/INF.27/Add.2.

All FBCs are subjected to periodic inspection in order to determining their applicability for further operation. Inspection is performed for the "safety factor" parameter by checking the residual strength of the carcass grid straps and for the "waterproofing" parameter by a corresponding check of the container body, visual inspection of seams and their gluing.

Inspection for the "safety factor" parameter is performed once every 3 years after commencement of container operation by taking carcass straps samples and determination of their residual strength as follows. All FBCs are divided into groups according to the year of manufacture. 3 FBCs are randomly taken from each group and samples are cut out from them. 30mm sections of load-beating straps are cut out in three points equally spaced along FBC circumference. The residual tearing strength of the strap is determined using 5000kg tensile-testing machine widely used at industrial enterprises. The residual tearing strength of the strap should be less than its minimal acceptable value. The minimal acceptable value shall be pre-defined by calculations for each FBC type based on the strength of 6:1 and shall be entered into FBC passport.

The results for FBCs tested shall be carried over to the entire group. This is the way to determine the safety factor for the carcass grids that underwent a repair. The cut-out sections of load-bearing straps are replaced with new ones as per the Repair Manual set forth in Attachment 1.

Inspection for the "waterproofing" parameter is performed once every 1.5 years after commencement of container body operation as follows. The container body shall be tested by filling it with air under the pressure of 10 kPa and pouring a water jet on it. A water jet is discharged from a tip (ID 12.5 mm) to all FBC outside welds and grooves, its pressure being approximately 100 kPa. The tip is kept 1.5 m away from the container being tested, and the water jet is moved with 100 mm/s. After this the body is turned inside out and is thoroughly inspected. FBC body shall be deemed waterproof if there are no water spots on the internal surface. Otherwise the body shall be accepted for use only for non-hydrophobic goods.

The results for FBCs tested shall be carried over to the entire group. This is the way to determine the waterproofing capacity of the bodies that underwent a repair.

The warranty period for FBC is one year.

3. Repairs

In terms of the intermediate bulk container (IBC) classification, FBC belongs to 13L2 type, being a container made of coated textile,

where 13 is the marking of flexible IBC for transportation of solids loaded or unloaded by gravity;

L is the marking of the textile used as a constructional material basis;

L2 is the marking for the coated textile used as a construction material.

FBC correspondence to this type predetermines the peculiarities of its use and repairing.

Constructively FBCs are serviceable, i.e. they allow for easy and operative repairing. Thus, in case of e.g. carcass grid repairs another FBC part – the body – may be used with another carcass grid, etc.

FBC repairs are carries out under the Medium Repairs Manual PP 016-007. There are three repair sewing and gluing operations on the container body aimed at its waterproofing ensuring. Sewing within the scope of repair operations are performed at Adler-166 or similar sewing machines. Prior to repairing FBCs are hung out and thoroughly inspected for identification of sections to be repaired. If only one section need repairs, the sewing and gluing operations will take on average 0.2 and 0.5 hour, respectively.

FBCs are usually assembled (also after repairing) by two workers. The time needed for FBC assembling in case of body replacement is 20 minutes. Preparation of FBC for further use is performed by one worker; it takes 8-9 minutes. FBC assembling or preparation for further use requires no special equipment and tools.

4. Use

Construction elements and materials used provide for long-term FBC service. The FBC service life is determined under the "safety factor" and "waterproofing" parameters. Dependence diagrams for these parameters are plotted on the basis of year-long observations of FBC use under various climatic conditions (including polar regions) and are given below.

The diagrams were plotted under the average FBC use parameters values.

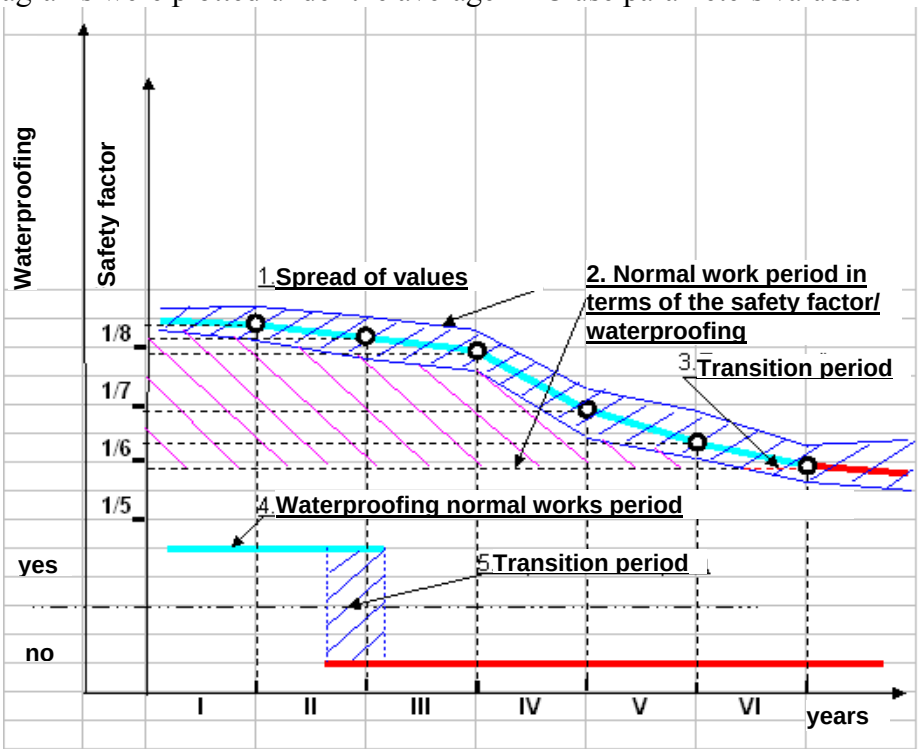

Fig. 1 Dependence of FBC operating capability in terms of "safety factor" and "waterproofing" on the service life

It is obvious from the diagrams that FBC operating capability in terms of "waterproofing" remains unchanged for 2 years, and the last 2-3 months are transitional. During this period chemical and physical properties of waterproof cloth deteriorate naturally under the influence of climatic conditions, and cloth loses its waterproofing feature. At the same time waterproof cloth is still capable of holding goods within FBC without spillages for several years, mostly for 6-7 years.

The diagram demonstrates that FBC operating capability in terms of the "safety factor" remains unchanged for 5-6 years.

Ad a result of environmental stresses the carcass grid straps start losing their strength, and FBC operating capability in terms of its safety factor deteriorates from the initial 8:1 to 6:1. This operating period is used for dangerous goods transportation.

Over another period of 1-2 the “safety factor” parameter reduces to 5:1. During this period FBCs may be used for transportation and storage of non-dangerous (typical) bulk materials. As it is seen from the observations, FBC safety factor decreases gradually over a number of years. In this context FBCs are systematically inspected as described in section 2. Testing.

Thus, when transporting hydrophobic dangerous goods, prior FBC service period elapses, one carcass grid and up to five container bodies are used in terms of the “waterproofing” parameter. FBCs completed in this way may be used for transporting those materials that the Standard Procedures permit to transport in BK2-coded containers, but that remain dry, solid and bulky over the entire period of transportation. The list of such materials is set forth in table 1.

Table 1

UN No.	Name and description	Class or division	UN packing group
3077	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S.	9	III

In case of transporting non-hydrophobic dangerous goods requiring ventilation, prior FBC service period elapses, one carcass grid and one container body are used. FBCs completed in this way may be used for transporting those materials that the Standard Procedures permit to transport in BK1-coded containers, but that remain dry, solid and bulky over the entire period of transportation.

The list of such materials is set forth in table 2.

Table 2

UN No.	Name and description	Class or division	UN packing group
1	2	3	4
1334	NAPHTALENE, CRUDE OR NAPHTALENE, REFINED	4.1	III
1350	SULPHUR	4.1	III
1454	CALCIUM NITRATE	5.1	III
1474	MAGNESIUM NITRATE	5.1	III
1486	POTASSIM NITRATE	5.1	III
1498	SODIUM NITRATE	5.1	III
1499	SODIM NITRATE AND POTASSIUM NITRATE MIXTURE	5.1	III

1942	AMMONIUM NITRATE, with not more than 0.2% total combustible material, including any organic substance, calculated as carbon to the exclusion of any other added substances	5.1	III
2067	AMMONIUM NITRATE BASED FERTILIZER	5.1	III
2213	PARAFORMALDEHYDE	4.1	III
3377	SODIUM PERBORATE MONOHYRATE	5.1	III
3378	SODIUM CARBONATE PEROXYHYDRATE	5.1	III

FBCs were used to transport over 315 thousand tons of dangerous goods with strict adherence to the environmental safety rules during transportation.

5. Handling

Basic handling operations involving FBC comprise loading, unloading, warehousing, loaded and empty transportation.

5.1. Loading

FBCs are usually loaded in one of the two following ways: either in suspension without the container bottom contacting the support, or in a holding basket with the container bottom support. In the first case FBCs are loaded using a spreader with FBC slings connected to it and the FBC loading arm is fixed to the central spreader pipe. FBC fixed to the spreader is moved to a batcher by the crane and after loading it is placed on a railway car or in the storehouse. In the second case FBCs are preliminary hanged in a holding basket placed on the truck or another means of transportation, and the FBC loading arm is connected to the batcher with quick-release clamps. After loading a truck moves to the FBC warehousing area or to the railway car loading area. FBCs are lifted from the holding basket with 8-hook spreader. In other cases FBCs are lifted with 8- or 4-sling crane load carrier.

When loading FBCs in suspension, the container freightage is maximal, when loading FBCs in a holding basket the container freightage is up to 5% less as compared to the maximal freightage. In both cases the requirements for environmentally safe operation are met to the full.

5.2. Unloading

FBCs are unloaded in suspended position. For this end, FBCs are lifted with a 8-hook or 8-lashing spreader. It is permitted to use 8- or 4-sling crane load carrier. When lifting with 8-sling load carrier all 8 FBC sings are strapped. In case of lifting with 4-sling load carrier, each hook will carry 2 neighbouring FBC slings.

Goods are unloaded from FBC through its unloading arm. In order to open FBC pull the dowel strap with the force of 20-30kg and pull out the first dowel (pin). It will open protective valves installed at the carcass grid bottom, and the unloading arm will fall out from FBC bottom centre, it being pulled over and fixed with the second dowel. The empty unloading arm is directed into the unloading tank, for example into the hopper car, tank-car, vessel cargo hold

hatches or into an open cargo hold, and then the second dowel (pin) is pulled out. Bulk goods will fall out from FBC. Usually the unloading time is 0.4-1.0 minute.

FBC is designed in such a way that unloading may be carried out from the zero elevation, i.e. during unloading the bottom part of the unloading arm may contact the surface to which goods are unloaded, and FBC itself is stretched in a line. As a result, there are no unloaded goods in FBC, and goods being unloaded do not generate dusting. Moreover, the requirements for environmentally safe operation are met to the full.

5.3. Warehousing

Loaded FBCs have the form of a regular cylinder 2.6m high and the fixed diameter of 2.45m along its height. Due to such dimensions FBC is a very stable container. FBC dimensions and shape remain unchanged during numerous shift associated with multimodal bilk goods transportation. Stable FBC dimensions and form allow piling them up into up to three layers putting each subsequent layer half the diameter inside the pile as compared to the previous layer. FBCs are piled by gravity, form and dimensions and are not secured. FBCs are piled with the help of cranes, manipulators, loading appliances and other hoisting devices. FBC are piled as a rule with gantry or automobile cranes. FBCs are transported to piles with loading appliances and cars. For FBC lifting with a loading appliance, a spreader fixed to the fork is used.

Such stockpiling is permitted by the Russian Competent Authority – Central Marine Research and Development Institute – and is successively used for FBC stockpiling in a number of ports and enterprises of Russia, Ukraine, Hungary, Romania, and Finland.

5.4. Transportation

FBCs are transported loaded and empty by any means of transportation, except for loaded FBCs transportation by air.

5.4.1. Railway transport

Russian Railways OJSC permits transportation of bulk goods loaded into FBCs in open-top (roofless) cars and unsecured. The only requirement is placing of 5 or 7 FBCs along the car axis depending on the car type. Such transportation is approved by the All-Russian Railway Transport Research and Development Institute.

Such a resolution was taken as early as in 1998 after in-situ dynamic tests of unsecured FBC for stability in case of sulphur loaded FBCs car collision. In addition the resolution was approved in 2009 after fuel pellets loaded FBCs car collision tests. During this period railway accidents involving FBC transportation did not took place.

5.4.2. Motor transport

In case of motor FBC transportation some safety precautions should be observed. For instance, mechanical transport should have the side height of over 2/3 of the loaded container height and should move at the speed of max. 50 km/h. If it is not possible to provide for such a side height, FBCs should be secured to the car body bottom plate with strings. See Attachment “Pictures. Transport/ Motor transport”.

5.4.3. Waterborne transport

In case of FBC transportation by river, sea and other waterways, FBCs are not required to be secured in vessel cargo holds provided they are placed close to one another. The Central Marine Research and Development Institute (Russian Competent Authority) permits multilayer FBCs piling in vessel cargo holds provided they are placed close to one another. Only in case it is impossible to place containers close to one another, for instance due to the vessel design peculiarities, they are loosened.

5.4.4. Empty FBCs

FBCs are reusable containers that is why empty FBCs redelivery after unloading is a process step.

Empty FBCs are transported folded by any means of transportation. In practice they are transported primarily by mechanical transport due to fast and accurate delivery. FBCs are loaded

to a carrier vehicle with a fork lifter. A 93m^3 truck may hold up to 260 empty FBCs. Such an amount is enough to load a 3600t DWT vessel.

6. Conclusions

Thus, for FBC handling gantry cranes, manipulators and hoisting devices will be enough.

In order to move FBCs, a special spreader will be required, but a universal 4-hook crane load carrier may be used as well.

No special transport is needed for FBC transportation.

No special equipment is needed for periodic FBC testing.

Special testing equipment will be required for some type tests of FBCs.


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