FlexiBin S3 report: testing summary and next steps

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Background Summary

Clive-Smith McKenna Limited (CSM), a registered UK company, have designed and patented a device (the FlexiBin S3) which addresses problems occurring in the flexitank industry which thus far remain unsolved. Of late there has been concern voiced by more than a few interested and influential parties at the level of risk involved with shipping in flexitanks.

The main focus of concern is aimed at the interface between the flexitank and the shipping container which together act as a transport system for the carriage if non-regulated and non-hazardous liquids. There have been some well-founded industry attempts at implementing measures to address and control the risks i.e. the COA COP and the latest PAS 1008:2014 document. In addition, certain operators of flexitanks have put in place processes and procedures to address these risks and safety concerns.

While the above efforts have indeed made an initial impact on reducing incidents they fail to address the full range of engineering and operational concerns associated with the system. These have been somewhat broached by various members of the industry in the past but more recently and more formally by organizations such as Germanischer Lloyd, DSV, and the CCIA (China Container Industry Association). At a recent meeting hosted by GL in Hamburg, World Maritime News reported as follows:

To end the presentations, GL's Viktor Wolf, examined the growing use of flexitanks in sea transport. Flexitanks are flexible plastic tanks designed to enable the transport of bulk liquids inside standard 20ft containers. Both the number of flexitank movements and the filling levels of those tanks were increasing, he said. In the absence of permissible filling criteria, there was potential for damage not only to the container enclosing the flexitank but the goods transported alongside. Buckling of the side wall of the enclosing container could result in the collapse of stacked containers, due to the weakening if the container frame. Mr Wolf set out GL's calculations for the maximum permissible loads based on the positioning of the container on board and the length of the vessel. The results indicated that, even in the best case scenarios, filling levels have to be considered carefully.

There has also been talk within the COA group around this issue with members putting pressure on the ISO Working Group member to support a 24 000 kg liquid payload figure against a move to reduce the latter to 18 000 kg.

These issues are unlikely to go away and are more likely to become increasingly prominent as the volume of trade in flexitanks grows and presents the industry with a challenging and growing problem.

While it can be said that some of the evidence put forward supporting the risks presented by flexitanks can be questioned most of this questioning comes from that segment of the industry which has most to lose from a commercial standpoint should payloads be reduced. This industry segment has somewhat of a history of producing shallow technical analyses in support of sometimes questionable outcomes.

There have been some veiled attempts to include reinforcing the container side walls to prevent damage but many of these proposals are not well thought through and have little or no technical merit.

So, to date the issues remain unresolved with no viable solutions offered. The CCIA and GL report do certainly raise some very real questions and concerns.

The main aim of this study is to in no way suggest a reduction in flexitank payloads. It is rather to show a way forward to responsibly maintain and increase payloads to ensure the future prosperity of the industry while at the same time improving industry economics.

What do CSM offer and why?

The unique technology proposed by CSM is a cost-effective solution with technical merit in that instead of trying to reinforce the shipping container structure to support the hydrostatic and dynamic liquid forces imposed by the flexitank, the FlexiBin S3 physically removes load from the container side wall and surrounding structure. This is a critically important difference between what CSM does and what others have tried to do in the past.

Based on our collective experience in the industry and taking into account our professional engineering training and detailed industry knowledge we undertook a strategic and critical scan of the industry and have determined there is a very definite need for a product which meets the following objectives:

1. Allows the industry to properly address the very real technical, operating and safety concerns outlined above
2. Allows the industry a way forward without negatively impacting industry economics by having a payload reduction forced upon it
3. Prevents shipping container damage and improves public safety
4. Allows a safe uptake of liquid payload to 27 000* kg thereby creating opportunities for responsible and sustainable industry growth
5. Provides a secure secondary containment system in case of a leak in the flexitank. The FlexiBin S3 can be used with an internal liner hung from the container lashing rings
6. Allows the pool of suitable containers to be enlarged by relaxing some of the existing container selection criteria
7. Allows the use of flexitanks in other container types i.e. 40' containers and reefers
8. Provides greatly improved heating capacity than any heater system currently on the market
9. Provides a cost-effective solution to the industry
10. Improves the risk profile and perception of flexitanks as a viable alternative to tank containers , drums and IBCs

*using FlexiBin S3 and a container with 2mm thick panels throughout

The FlexiBin S3

The FlexiBin S3 is very simply a lightweight high strength demountable receptacle which safely accommodates flexitanks in containers by removing liquid load from the container side walls. Figure 1 below indicates the concept. The accompanying technical presentation pack can be viewed separately along with a full engineering analysis.

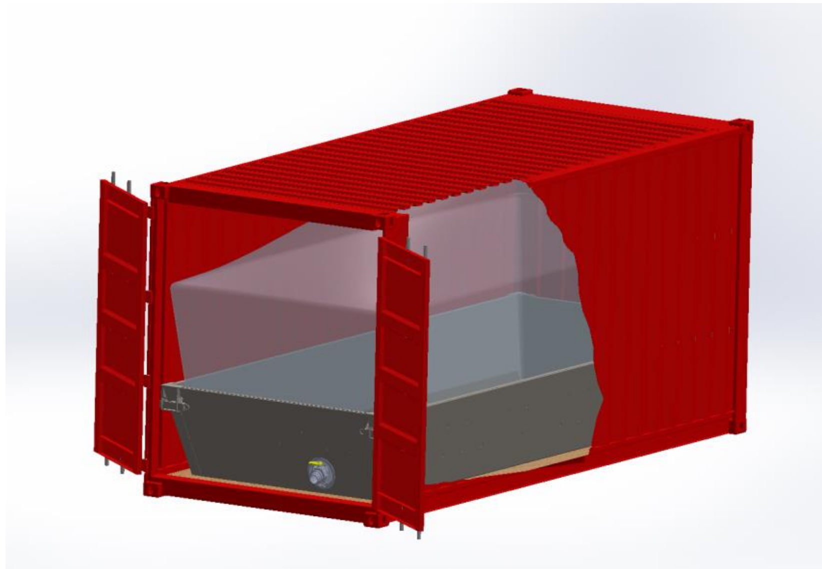

Figure 1. FlexiBin S3 concept

Using a standard 24 000 kg flexitank the FlexiBin S3 physically removes over 6 600 kg of load from the container side walls. Not only does this remove load but also allows for greater liquid payloads up to 27 000 kg to be safely carried without concern for container side wall failure. This is the real economic benefit of the system.

Testing

a. Methodology

Physical testing on the FlexiBin S3 took place in the UK on 3rd July 2015.

Testing was carried out in accordance with the following sequence:

1. Two new 30t rated ISO type 22G1 containers in good condition were leased alongside a 100t capacity mobile crane. The side wall construction on both containers was a panel thickness of 1.6 mm throughout
2. One container was fitted with a BD240 flexitank and standard bulkhead

3. The other container was fitted with a bottom fill/discharge 24 000 liter capacity flexitank and a FlexiBin S3. No bulkhead was fitted. Two steel tubes 50 x 50 x 3 were fitted across the door opening at approximately 400 mm above the FlexiBin S3
4. Using a calibrated in-line flowmeter both containers were filled with 24 000 liters of water and leveled using steel plates under each of the four lower corner castings. See figure 2
5. A load cell was fitted to the crane hook to calculate overall and component weights
6. After leveling measurements baseline measurements reference points were established at three positions along the side wall. See figure 3
7. Using the crane and a plumb bob and protractor each container was in turn gradually rotated about its longitudinal axis in increments of 5 degrees. See figure 4

Figure 2. Containers leveled using steel plates

8. After each rotation a physical inspection of the side walls were conducted and the deflection recorded at three positions
9. Once testing was completed on both containers with 24 000 kg liquid payload, the container with the FlexiBin S3 was filled further to 26 000 kg liquid payload and rolled through increments of 5 degrees and side all deflection measurements recorded as before

Figure 3. Measurements refrerences

Figure 4. Rotating the container. Protractor and plumb bob on LH door

Figure 5. Testing arrangement

b. Results

After each angular rotation increment the container side wall deflection measurements at all three points were recorded.

The first container with 24 000 liters of water and without the FlexiBin S3 failed at an angle of 25 degrees. Side wall failure is indicated in figure 6. At 25 degrees roll the panel was stressed beyond its yield point and buckling of the corrugations occurred which is typical of the type of failure seen in the field.

Figure 6. Failure of side wall panel. Measurement points shown

The container with the FlexiBin S3 and 24 000 liters of water was rotated all the way to 38 degrees with no failure or signs of stressing the panel beyond its material's yield point. This deformation was clearly still within the elastic limit of the material.

This second container with the FlexiBin S3 was then filled with a further 2 000 liters of water resulting in a total liquid payload of 26 000 kg and the angular rotation sequence was repeated for this container. This container was rotated through 30 degrees with do damage exhibited. The test was halted at 30 degrees due to safety concerns with regard to the container overturning much beyond this angle.

Analysis of results

The results provide an objective and practical verification of the design intent of the FlexiBin S3 namely, to provide a mechanism to remove load from the container structure in such a way to make it safe to transport liquid payloads up to 26 000 liters.

This addresses two key issues namely, that it is possible to safely carry a higher liquid payload up to 26 500 liters (subject to local bridge laws) and the fact that even at this higher payload the container side walls do not sustain damage. The important economic benefits of this for the flexitank industry have been highlighted in a separate financial analysis.

There has been market talk about liquid sloshing and the COA and the PAS 1008:2014 documents contain testing to address this. However, in our view, this longitudinal sloshing is not the main concern. This can be evaluated by looking at the sloshing forces and frequencies. Shunting a 24 000 liter flexitank in a 20' container produces an additional pressure of just over 1.53 psig at 2g. This is not sufficient to cause damage to the side wall. The sloshing frequency (of water) at this input pulse is 0.328 Hz. The highest and lowest modal resonant frequencies of the side panel are around 68 and 51 Hz respectively. The frequency ratios in both cases result in no acceleration or load amplification. A similar case can be shown for lateral sloshing.

Based on our calculations and detailed understanding of the liquid dynamics involved we do not believe that the current set of industry tests adequately addresses the failure modes of containers in service when loaded with flexitanks. We are of the opinion that the forces causing damage to containers derive from vertical lifting, lateral forces, rolling on vessels and, particularly, from a combination of the latter.

In the attached document Full container FEA we have included, *inter alia*, the finite element analysis (FEA) analysis of two of these scenarios as follows:

1. Vertical lifting at 2g with 24 000 kg liquid payload without the FlexiBin S3 and the same test with 26 000 kg of payload with the FlexiBin S3 (slides 13 through 15)
2. A 30^0 container static and dynamic roll without and with the FlexiBin S3 at varying payloads ranging from 24 000 kg to 26 000 kg (slides 16 through 23)

Based on the high levels of accuracy and reliability of the CAD/FEA models we have expanded the FEA analysis to investigate the effectiveness of the FlexiBin S3 under load various conditions and have proposed a set of safe loads with and without the FlexiBin S3. These loads are outlined on slide 9.

CSM can conclude that the results of the testing are in line with our calculated outcomes and that the results sufficiently correspond to our modelling and FEA of the system confirming the accuracy and reliability of the modeling.

Next steps

As the results of the testing proved to be in line with expected outcomes CSM are now ready to move forward with field testing of the product under love operating conditions.

In order to do so CSM would like identify a partner/s or operator/s willing to take into service at least 2 of the 3 units built and test *in situ* over a period not exceeding 4 months.

a. Next steps

- CSM will make some minor modifications to the existing FlexiBin S3 units to improve operational handling – completed by 30th April 2016
- CSM will build and provide the stacking and handling frames to support the field testing of the prototype units

- Operator/s to implement FlexiBin S3s on trade lanes which will allow maximum payload and round-tripping and report back to CSM – field tests completed by 30th September 2016

Joint development

It is proposed that CSM and selected Operating partner/s (Partner/s) jointly develop the FlexiBin S3 in accordance with the immediate next steps described above.

If, after the end of this time period or at some other period agreed by all parties (CSM and Partner/s), all parties are of the opinion that it is in the best interests of all or some of the parties to continue development then CSM and Partner/s will at that time agree to jointly pursue further development goals and objectives.

If the parties cannot agree on this then CSM are free to continue with their own development program.

It must be pointed out that CSM believe there is a sizeable market for the FlexiBin S3 and that a single Partner alone probably cannot provide total market penetration. However, CSM are open to discussing a formal agreement whereby Partner/s is/are offered favored nation status for an agreed period of time considering their efforts in assisting with the product development phase.