WHITE PAPER #4

TESTING.

A BEST-PRACTICE APPROACH

SHIBATAFENDERTEAM

on the safe side

Contents.

Executive summary.

The fourth and final part of the SFT White Paper Series follows up on the previous three parts #1 to #3, which established in-depth illustrations of compounding, mixing, manufacturing, and curing. SFT White Paper #4 completes the Series with a thorough examination of testing methods for fender systems, best-practice approaches to verifying the required performance properties and the durability of a commercial fender. The paper highlights the significance of testing by transparently explaining how to interpret the test results of the different tests. It can be used as a practical, hands-on guide for clients to the ideal approach to the complex fender testing agenda based on the point of view of an experienced manufacturer.

The overview of the four test methods – fundamental, durability, type approval and verification testing – presents valuable information on current industry practice and basic knowledge of fender testing in general.

The main focus of the paper lies on verification testing since it is the most relevant test area to assure the client that the final fender has been manufactured precisely as ordered. The five different parts of verification testing (material testing, traceability, performance testing, verification of dimensions and visual checking) are explained including the most important factors for performance testing. A reflection of industry requirements, practical information on the most frequent and essential issues regarding correction factors, how to deal with deviations and meeting the required test results have been included in a Q&A section.

Moreover, Paper #4 covers the essentials for Pneumatic Fenders, Foam Fenders and Steel Panels for a 360-degree coverage of the subject.

SFT Whitepaper Series:
#1 Compounding | #2 Mixing | #3 Curing | #4 Testing

SFT White Paper Series.

Since fenders are designed to create a safe environment for ships, passengers and port infrastructures, safety, reliability, and durability are extremely relevant during the design life of a fender and beyond. **The quality of a fender can exclusively be measured by its physical properties and its performance in its specific field of application.** Every fender project is unique and a customized solution for the respective case and scenario. **The White Papers aim to share SFT's profound knowledge and expertise with the industry and to take a close look at what exactly makes a good fender – from source materials and manufacturing processes to testing.**

Along the SFT White Paper Series (Compounding. A Winding Road, Mixing. A Step By Step Operation, Manufacturing and Curing. Advanced Perfection), relevant manufacturing methods have been described and it has been shown that there is no guideline or standard specifying the chemical composition of the rubber or compulsory provisions regarding the mixing and manufacturing processes. **The international guidelines and standards like PIANC2002, ASTM D2000, EAU 2004, ROM 2.0-11 (2012) or BS6349 (2014) do, however, ensure that fenders perform as designed when installed at the berth and define the mandatory physical attributes of rubber fenders. This is why the results of the various testing methods are so important: They are the final and essential proof that a fender possesses the required physical properties and is a high-quality product that is ready to meet every berthing challenge it may encounter.** In order to create space for this important topic, the White Paper about fender testing concludes the four-part SFT White Paper Series as one of the most vital steps in fender manufacturing.

SFT Whitepaper Series:
#1 Compounding | #2 Mixing | #3 Curing | #4 Testing

As an experienced manufacturer, we at the SFT Group consider contributing to high quality standards in the industry as one of our main responsibilities which are driven by our strong commitment to holistic fender design and manufacturing.

SFT White Paper Series – #4.

The characteristics of a rubber compound and its behavior during the mixing, manufacturing, and curing process is complex. As we have learned from the previous SFT White Papers, the required physical properties of a fender can vary depending on the project, which is why they are manufactured specifically for each assignment. **White Paper #4 provides guidance and best-practice examples of the different test methods and how they are performed.** It is divided into three sections: an overview of different test methods (Section A), a main focus on verification testing (Section B), and additional information regarding Pneumatic Fenders, Foam Fenders, and Steel Panels (Section C). The paper prioritizes verification testing with practical advice on what to consider from a client's perspective and a guide to frequent issues regarding correction factors, deviations, and how to handle certain challenges that might occur during the testing process.

The document contains essential information on fender testing practice according to the current international guidelines and standards and demonstrates the recommended testing approach from the perspective of a trust-worthy, reliable and experienced fender manufacturer.

A. Overview of Different Test Methods.

There is a number of different test methods for different testing purposes, for example to obtain a type approval for a fender, to establish standard catalogue values, to test durability, physical properties, or performance. **The different methods are based on international standards and widely accepted recommendations. Some of the tests are conducted prior to a client's order, for example during the development phase of the fender.** Verification testing ensures the client to be able to examine the final fender and to verify that he receives exactly what he ordered. Four different test methods are outlined below.

Fundamental Testing

↳ Durability Testing

Type Approval Testing

Verification Testing

Figure 1: Overview of different test methods

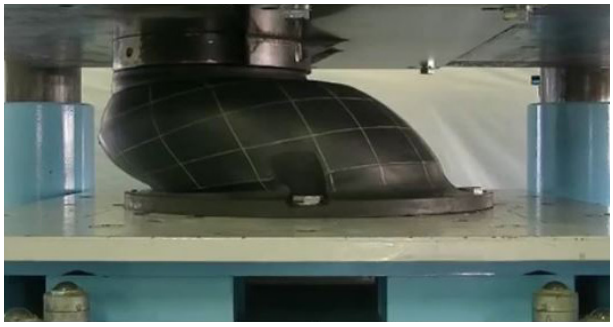
Fundamental Testing

Fundamental testing is carried out using a scale model to establish catalogue performance data and to determine correction factors which are the fundamental data for a product type approval. Since these tests are designed to test, as a minimum, those kinds of conditions and situations as defined within industries recommendations, fundamental testing is not suitable to be performed for every fender project due to the high time and cost expenditure. Fundamental testing is mainly applied in the development of fenders to achieve general technical data or a one-time specification of catalogue values. Published fundamental testing data include standard performance, correction factors (e.g. temperature, velocity, angle) and test results, whereas any technological research and development results are used exclusively by the manufacturer for product improvement and remain confidential.

Durability Testing

Durability testing, as part of fundamental testing, is performed once per fender type on a fender not smaller than the smallest commercially sold fender of the same model. **The test procedure imposes long-term fatigue on the fender in a short period of time and evaluates its durability. The temperature-stabilized fender sample is exposed to a repetitive compression to its design deflection which means 3,000 or more cycles of compressions at a maximum period of 150 seconds per cycle, pursuant to the agreement between the manufacturer and the client or the applicable guideline.** Durability testing can typically not be performed on full-size fenders. The set pass/fail criteria for durability testing require that the tested fenders do not have cracks that are visible to the naked eye. **As long as the fender type or the production method has not changed, there is no need to do a new test for each new project.**

Alternatively, a combined shear compression testing is recommended instead of the simple compression test. This test combines shear deflection with axial deflection. At SFT, the combined shear and compression test equipment allows for almost any fender size to be tested, yet the number of compression cycles is inherently limited for the largest fenders. For scale models, 25,000 and more test cycles are possible and have already been successfully tested under full time external auditing. **In general, durability test cost should not be underestimated, as certain test protocols can lead to tens of thousands of dollars in additional cost.** Before this test is required in specifications, the client should consult with the manufacturer for details and prices to clear the necessary budget for it.



Shear compression test

Type Approval Testing

In order to obtain a product type approval or type examination certificate for a fender, the respective tests need to be witnessed and verified by a certified third party. **The minimum test scope includes standard performance, durability, correction factors and physical properties as published in the catalogue.** A product type approval is usually valid for five years and needs to be renewed after the validity period. **It should be noted that only certificates that have been uploaded on the certifying body's website are true and valid.** Throughout the validity cycle, periodical assessments need to be carried out to constantly review manufacturing processes.

Examples of SFT Product Type Examination Certificates – for verification, please check: https://approvalfinder.dnvgl.com

Verification Testing

The tests for final fenders and material used serve to demonstrate the performance and material quality of the product. The tests are performed on the actual material and fenders that are produced for a project. **Once the specific parameters and requirements for a project have been determined, it is the manufacturer's task to ensure the final fenders and the material used are compliant with the client's individual project requirements.** Verification testing ensures that final fenders have been produced according to the respective project specifications and/or catalogue values.

Verification testing consists of material testing, traceability, performance testing, verification of dimensions, and visual checking, which are covered in more depth in section B of this paper. **Material testing is performed on the actual material used for the production of the fender, whereas the other test procedures are performed on the final fender that has been produced for the project. In contrast, fundamental or durability testing is typically done on a scale model.**

TESTING METHOD	DEFINITION / AIM	TEST TYPE	METHOD OF DISCLOSURE	PRACTITIONER
FUNDAMENTAL TESTING	Determination of general technical data and establish correction factors	Compression under several conditions, material, durability, performance, etc.	Manufacturer's own disclosures, catalogues, website	Manufacturer and / or third party
DURABILITY TESTING	Evaluating durability	Repetitive compression to design deflection		
TYPE APPROVAL TESTING	Obtain type approval certificate	Standard performance, durability, correction factors, physical properties	Certification documents issued by third parties	Witnessed and verified by third party
VERIFICATION TESTING	Verify that fenders have been produced acc. to project specifications or catalogue values	Material and performance testing, traceability, verification of dimensions and visual checking	Test report by manufacturer and/or third party	Manufacturer and / or third party

Table 1: Comparison of different testing methods

B. Verification Testing – the Details.

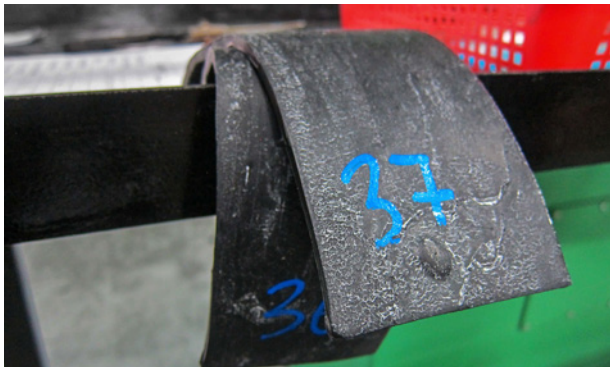
Verification testing is the method to determine that the clients receive exactly what they have ordered. **This test procedure is of utmost importance for the client because it confirms the quality of the product before it is shipped and installed on the berth.**

It is important that the project specifications already include the client's test requirements and the important project-related parameters beforehand, amongst other things to be able to budget the testing cost ahead. It is critical to know that special test requirements come at a certain cost, and it is advisable to plan the testing budget in advance. **Requiring testing beyond industrial standards influences the overall project budget and depends on the size and significance of the project.** If the client, for instance, only buys two fenders as spare parts, comprehensive test requirements that would lead up to tens of thousands of dollars would not be justified. Another important factor is the delivery time: With a tight project schedule, not all fenders can undergo full testing because particular testing requirements and especially third-party testing might exceed this schedule. **A detailed specification is key, and it is highly recommended to consult with a trusted and reputable fender manufacturer to get assistance and advice on all project-related requirements.**

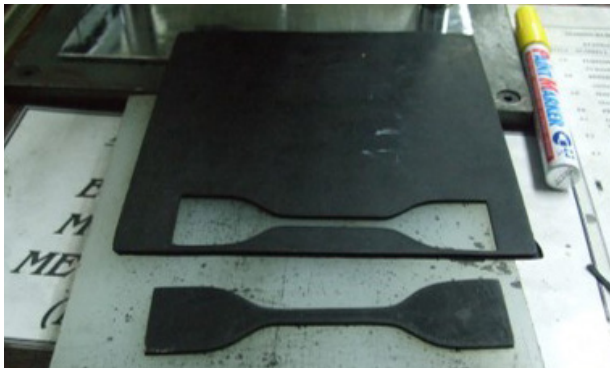
According to the industrial standards for verification testing, there are typically two different procedures how the test can be performed. **The in-house standard testing can be conducted by the manufacturer**, or the client or manufacturer selects a **third party as a testing witness and the testing is performed at the manufacturer's facilities with the manufacturer's equipment.** The third party witnesses the test and verifies that all equipment is calibrated and holding valid certification at the time of testing. **This process is best practice and recommended contrary to other individual solutions that can be agreed on between the manufacturer and the client.** The following sections describe the five different parts of verification testing: material testing, traceability, performance testing, verification of dimensions and visual checking.

Material Testing

Rubber compounds can have very different chemical compositions depending on their required performance criteria which have to comply with international standards and guidelines like PIANC2002, ASTM D2000, EAU 2004, ROM 2.0-11 (2012), or BS6349. These guidelines ensure that a fender performs as designed when installed at a berth.



Test specimen from final compound for material testing



Test sample made from specimen taken from final compound

The rubber samples that are needed for the material testing are taken from the finalized compound and are precisely prepared and then cured in the laboratory. Afterwards, they are tested for their physical properties under strict laboratory conditions including tensile and bonding strength, compression set, hardness, elongation, tear and abrasion resistance, chemical and ozone resistance, and aging.

The test standards ASTM, DIN, JIS, and ISO, which are all very similar in both procedure and limitations, prescribe the exact shape and thickness of the rubber samples and the test procedures. Reference range for test results are typically based on ASTM D2000. **It is vital to strictly adhere to the respective standard which not only applies to the preparation of the test samples, but also to the correct storing and how soon after the production the samples have to be tested in order to avoid test results out of the reference range and deviations to test results of the manufacturer.** Detailed information regarding the testing requirements can be obtained from the manufacturer.

Traceability

Traceability is done to verify that the final fender was produced from the same compound which was used to test physical properties during material testing. For this purpose, a TGA test (thermogravimetric analysis) needs to be performed to compare the composition of the two rubber samples from the final fender and from the material test. It is only important that the values match/are consistent, regardless of the actual value. The test setup is as follows: A small sample is taken from the final fender and a TGA test is performed. A TGA test is a method of thermal analysis in which the rubber sample is continuously weighed during heating. As different components burn off at different temperatures, the reduction in weight provides an indication of the sample's composition. These results are compared to the TGA test which had been performed from the rubber sample of the finalized compound, initially used for material testing. **If the results from both TGA tests are consistent, it is verified that the final fender consists of the same compound that was tested for physical properties during the material testing.**

However, it should be noted that deviations in labs or between labs can occur. The laboratory conditions may vary between the laboratory which conducts the TGA test on the material test sample (usually manufacturer) and the laboratory which conducts the TGA test on the final fender sample (usually an institute instructed by client). On the other hand, small differences within the fender body can occur – amongst others due to mixing variances – so that the sample which was taken for traceability may have a slightly different composition than the sample taken from

MATERIAL TESTING	TRACEABILITY
Done by manufacturer	Done by manufacturer or independent institute
Test specimen is taken from finalized compound	After curing, small sample is taken from final fender
Test samples are precisely prepared acc. to standards	Sample should be small to not damage the fender, typically 50-100 g
Test samples are cured in laboratory	
Test samples are tested for their physical properties under laboratory conditions	
TGA Test is done for sample from compound	TGA Test is done for sample from final fender
Soxhlet extraction is recommended; in any case, procedure should be the same for both tests	
TGA Test results from both are compared to check if they match	
Test results consistency: final fender has been manufactured from the compound with which the material testing has been done	

Table 2: Process of material testing and traceability testing

the batch. These irregularities are common and do not affect the fender performance. Additionally, the occurrence of the above-mentioned deviations can also be expected if both the manufacturer and the institute do a TGA test on samples from the same fender.

If the traceability test from the final fender is not performed by the manufacturer, the client needs to make sure that it is done by a certified laboratory (e.g. certified acc. to ISO 17025), which is experienced in rubber testing. Furthermore, it is important that the laboratory is independent, and the test equipment is calibrated thoroughly.

However, it should be noted that TGA is a quantitative analysis only, and does not provide any indication about the quality of the fender.

Before the TGA is conducted, a Soxhlet extraction should be done by adding a solvent such as acetone to the rubber which then extracts the chemicals. If this step is left out, the polymer content shows values that are higher than they usually are. **The Soxhlet extraction is recommended to obtain more precise results and to optimize the comparability between the test of the rubber sample and the one from the final fender.** It is obligatory that both tests follow the same rule – either a Soxhlet extraction is done for both samples or for neither, as otherwise, results will deviate tremendously. For this reason, it is extremely important that the client or laboratory which conducts the test on the final fender knows if the Soxhlet extraction has been done by the manufacturer.

It is sometimes questioned within the industry why physical properties testing should not be performed on the final fender itself instead of preparing test samples from the compound before production. Testing physical properties from final fenders is unusual and extremely difficult since it would involve cutting a large piece out of a final fender which could damage the fender. The reason for this is that a lot more material is needed for the physical properties testing than for the traceability (TGA). Also, deviations of 15-20 % to the catalogue values need to be taken into account because there is a big difference between the results from a piece of the fender body or a test plate cured and prepared under laboratory conditions. Additionally, curing a fender is different to curing a small test sample – it is almost impossible to match the physical properties to those on any section of the product.*

Performance Testing

Performance testing is also known as factory acceptance test (FAT) and is performed on the final product to ensure that it fulfills the performance requirements. Typically, and if the client and the manufacturer do not agree otherwise, 10 % of final fenders are tested.

The fenders that are tested are selected randomly which can be done by the client if he supervises the testing process. They are compressed in a large test press or test frame until their design deflection, while the reaction force is measured with load cells and/or pressure transducers. It is especially important for large fenders that the test frame has sufficient stroke in order to reach the required deflection of the fender. **There is only a limited number of test frames available worldwide for large-size fenders, which is why performance testing is usually conducted at the manufacturer's facility.**

Performance Testing

* Technical Standards and Commentaries for Ports and Harbour Facilities in Japan

THE FOUR MOST ESSENTIAL FACTORS THAT NEED TO BE TAKEN INTO ACCOUNT FOR PERFORMANCE TESTING

01 Temperature Stabilization

After curing a fender, heat remains in the rubber body, and it is important that the fender temperature is stabilized prior to the performance testing. This means that a fender is exposed to a certain temperature for a certain amount of time in order to achieve a uniform temperature distribution throughout the entire fender.

The uniform temperature can be achieved by leaving the fender in the ambient temperature of the manufacturing facility or by using a temperature stabilization room. Temperature stabilization rooms are available at the manufacturer's site, but the room space is limited so that only a few fenders can be stabilized at once. Therefore, if specific stabilization temperatures are required, testing times can be extended by up to several weeks.
Example: When coming out of the mold, a Cone 600 Fender takes about one day, whereas a Cone 1800 Fender takes up to 7 days until the entire fender has reached the same temperature from the outside to the core.

Temperature Stabilization Room

There are two options available for performance testing:

- The fenders are stabilized and tested at ambient temperature. The test results are adjusted to the guideline / standard or a project-specific temperature by applying temperature factors. **This method is known as the most efficient and economical setup.**
- The fenders are stabilized in the temperature stabilization room according to the guideline or project specifics without allowance for temperature factors. The testing time might hereby increase substantially along with the testing fees.

02 Fender Break-in

The break-in cycle is usually known as at least one full time compression to the fender's design deflection after the manufacturing process. The reaction force of this first compression deviates from the catalogue value and is not representative for the fender performance during its service life and beyond. The break-in cycle is typically recommended for large fenders with high reaction forces. Molded fenders can exhibit fragile or temporary bonds that have to be broken so that the fender can reach its required long-term performance properties.

The fenders that were chosen for performance testing typically undergo a minimum of three compression cycles during which special attention is paid to the 15 to 20-minute resting period in between the compressions. After the third compression, the resting cycle is extended to at least one hour after which the actual testing process is introduced by the fourth compression cycle.

03 Correction factors

If the test conditions differ from the design conditions, correction factors are applied in order to achieve comparability. These correction factors are established during fundamental testing. Comparable data is achieved by comparing the test results either with catalogue data or project-specific requirements to observe if a fender meets the requirements and to conclusively verify its performance.

Typical correction factors are test speed (VF; Velocity factor) or temperature range (TF; Temperature factor). There are no independent test frames that are able to test fenders with the actual berthing velocity and therefore, a constant slow velocity (CV) is applied during testing according to the PIANC WG report 33 (PIANC 2002).

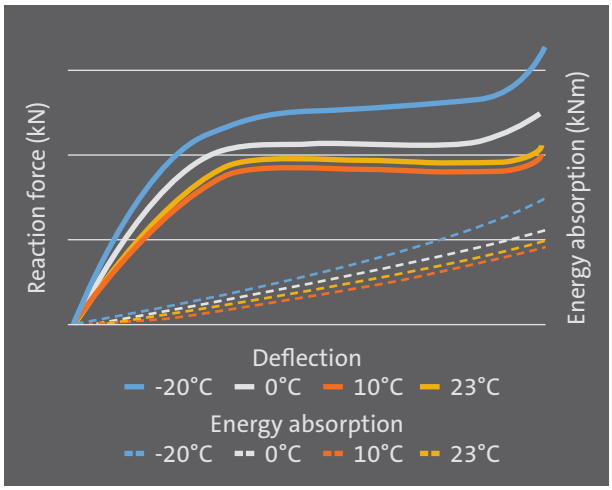


Figure 3: Results of performance testing at different rubber temperatures

Example calculation of applying the temperature factor

- Fender is tested at 30° (stabilized in manufacturing facility's ambient temperature); testing result: 766 kNm
- Temperature correction factor at 30° is 0.976 (this value has been established during fundamental testing)
- Energy absorption corrected for temperature factor: 766 kNm / 0.976 = 784 kNm
- Result after correction factor (784 kNm) is compared with required minimum value (for our example 782 kNm)
- The fender's energy absorption meets the minimum requirements

04 Pass / Fail Criteria

During performance testing, the fender is deflected up to its design deflection and passes the test when the minimum energy is met at any point during the test without exceeding the maximum reaction force. On that note, it is important to mention that deflection is not a pass/fail criterion* and the fender passes the test even if energy and reaction is met prior to the design deflection.

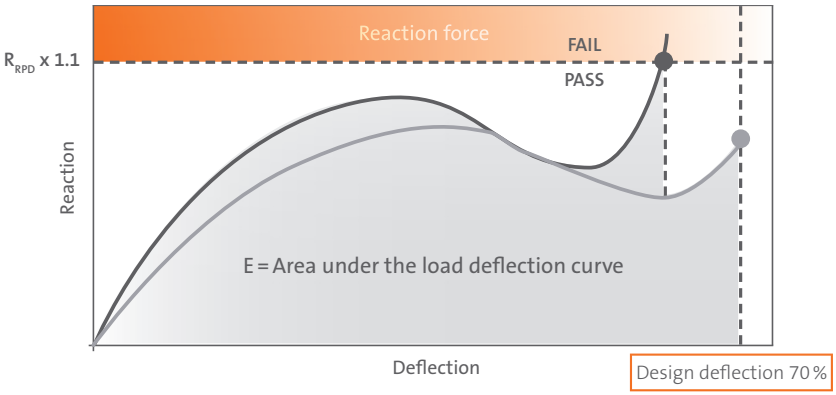


Figure 4: Load Deflection Curve

Two fenders are compressed to the design deflection of 70. One of the fenders reaches its minimal energy and maximum reaction force prior to the design deflection, the other one at the design deflection: Both fenders pass the test.

* PIANC: 2002 Section 6.1.2, ASTM F2192 Item 7.1.2

Verification of Dimensions

The dimensions are checked and compared to the catalogue data and should be within the manufacturer's tolerance. When measuring the dimensions on the production site, thermal expansion and contraction need to be considered. Deviations in dimensions between fenders are rare since they have been produced in the same mold.

Dimensional check

Visual Checking

In the course of verification testing, the final fender is examined visually to check its appearance for cracks or defects. If the fender exhibits minor appearance salience, the product is touched up. **Usually, the appearance saliences do not affect performance.** Fenders can have surface flow marks, which is a usual occurrence as long as they are not too extensive. If they are only an aesthetical issue, they do not have any effect on the quality. If the defect area is large, the client needs to consult with the manufacturer.

Furthermore, in the event that a cylindrical fender is oval, it might need to be reproduced.

Appearance salience (should be repaired or replaced)

SFT's Best-Practice Guide to Frequently Asked Questions.

The following part deals with important issues, challenges and questions regarding the verification of correction factors, how to categorize and handle deviations of test results and what happens if a product does not meet the requirements.

Q **What is the best practice to verify correction factors?**

A It would be possible to verify the correction factors once again for a specific project, but it is standard practice to apply the correction factors preassigned in the type approval testing. The important question to consider in this context is how the test protocol and setup for the original definition of correction factors looked like and to match the original setup for new tests to achieve comparable data. Slight deviations can occur and are the norm – even with the exact same setup.

The best practice here is achieved when the manufacturer has a type approval as correction factors are calculated and established during this process. The type approval should be certified by an independent, reliable body and it is as always advisable for the client to work with a trustful supplier with a proven track record. An additional layer of trust can be created when the establishment of the correction factors has been developed together with an independent entity, for example a technical institute, such as the Kyushu University in Japan. In any case, if it is requested or required for any reason, correction factors can be tested again. Since this test is conducted under laboratory conditions, additional time and costs are incurred. **However, if the order is placed with a trustful supplier, proceeding with another test is rarely necessary or justified.** On a side note, it often happens that correction factors are questioned when it comes to testing, although there is actually no logical reason for this: **The fender system has been designed according to the very same correction factors that are applied during testing.**

Q How to deal with deviations between test results and catalogue data? What is the process when deviations occur?

A **The best-practice procedure to handle deviations is to establish a very clear communication throughout the project and for the client and the manufacturer to agree upon the procedure before the tests start.** The test protocol must be distinctly determined between both parties. Deviations do not automatically imply that a bad product was delivered or that the material is of low quality. In case deviations occur, the manufacturer can double check the calibration of his test equipment and review test conditions. The next steps would be to check the results of the material test and the molding and curing process.

A potential reason for deviations is that the test protocol was not followed. For example, the fender has not been temperature stabilized and therefore tested with an incorrect temperature, or the set time between each test cycle for performance testing might have been neglected. **Not adhering to test protocols alter test results and make them incomparable with the catalogue data. Yet, this does not speak for a bad product, the results simply cannot be compared.**

Q What if everything has been followed but there are still deviations?

A If the final test results still feature deviations, even if all the possible reasons have been eliminated, the manufacturer will consult with the client if the product can be accepted under certain conditions. **In this case, the degree of the deviations needs to be balanced against potential consequences on the fender performance or its installation. The decision will be made on the basis of a careful assessment and agreement between manufacturer and client.** Some deviations are neglectable, such as some millimeters of dimensional differences for example.

Q What if the product does not meet testing requirements?

A In case the verification test results do not meet the required values within the corresponding tolerances, retesting is performed using two more sets of samples or fenders from the same mixing lot. The fender which did not pass the test is rejected and will be produced again. If all the additional samples pass performance testing and all other quality verification tests, it is acceptable to assume that the remaining fenders comply with the requirements as well.

C. Additional Information – Foam Fenders, Pneumatic Fenders and Steel Panels.

The same principle that applies to every aspect of fender manufacturing is also valid for testing: Different fender projects as well as different fender types require attention in distinctive criteria. This section summarizes the key points for testing Pneumatic Fenders, Foam Fenders and Steel Panels.

Foam Fenders

For the performance verification of a foam fender, it is important to define if a scale model or a full-size fender is tested (according to ASTM 2192, scale models need to be used for large fenders). The typical performance tolerance of a foam fender is +/- 15 %, the recommended dimensional tolerance lies at +5 % / -0 % or as agreed between manufacturer and client.

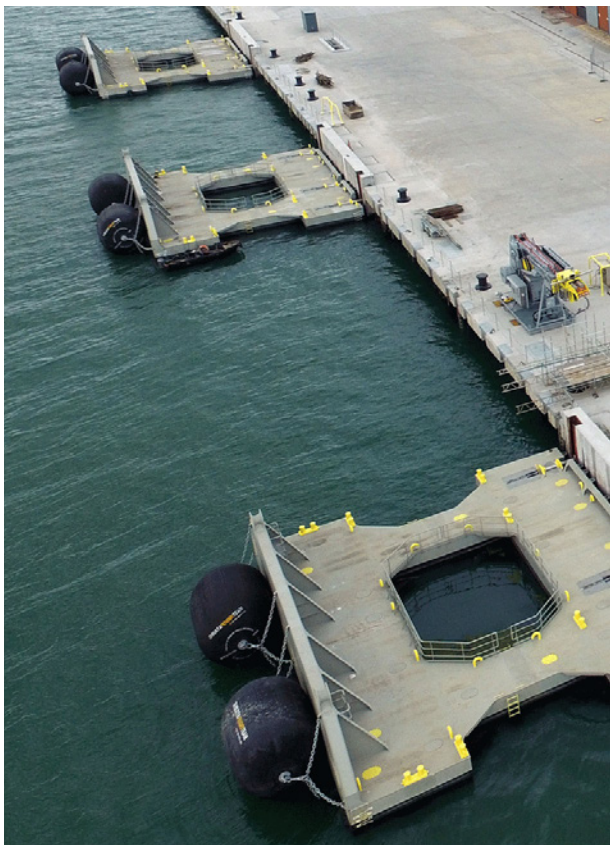
Further tests examine the fender's skin thickness, its foam density and fender pull-through. **For more information, please consult with the manufacturer and make sure to agree on a test protocol which is then strictly followed and on how deviations are handled.**

Pneumatic Fenders

The material test of the outer rubber and the inner rubber shall be conducted in accordance with the information specified in ISO 17357. The dimensional inspection has to be performed at initial internal pressure and lies within a tolerance of +10 % / -5 % in length and diameter.

Pneumatic Fenders are tested for air leakage which shall be conducted on all fenders at the initial pressure for more than 30 minutes. The test results have to confirm that there is no air leakage.

The performance of high pressure floating pneumatic rubber fenders shall be specified in terms of guaranteed energy absorption (GEA), reaction force at GEA deflection, and hull pressure at GEA deflection. These tests shall be performed using an actual-size fender or a scale model larger than one fifth the size of the actual diameter.



Pneumatic Fenders

Steel Panels

Steel panels for fender systems are usually protected against corrosion by a coating system according to ISO 12944. **The panels need to undergo paint thickness inspections to check the coating thickness and to carry out touch-ups if necessary.**

In order to check for airtightness of the panel, a panel pressure test is performed. This is a very common test, which is easy to be performed on the construction site: The panel is put under pressure and by using a soap spray around the exterior welds, the airtightness can be examined. Occurring bubbles are a sign of air leakage. In this case, the welds need to be repaired by additional welding and checked again afterwards.

For further test requirements, it is recommended to coordinate a detailed ITP (Inspection and Test Plan) with the manufacturer.

Steel Panel

Conclusion.

A high-quality fender is the result of expertly composed and coordinated compounding, mixing, manufacturing and curing, and testing processes that belongs in the hands of an experienced manufacturer. **Testing guarantees that the performance and physical properties of the final fender meets individual project requirements as well as international standards, which is one of the reasons that it is advisable for the client to consult with the manufacturer and to put a strong focus on this phase of fender manufacturing.**

This White Paper finds that establishing a detailed testing protocol prior to testing is key, and it is highly recommended to consult with a trusted and reputable fender manufacturer to get assistance and advice on all project-related requirements. Furthermore, a clear communication regarding correction factors and deviations are vital to ensure that the final fender is delivered as ordered by the client.

An experienced fender manufacturer will consider every important aspect of the highest quality standards and find the optimal balance to the cost-performance ratio, in particular when it comes to testing. **Dealing with the test methods incorrectly can lead to additional time and cost expenditure that can be avoided by establishing the most adequate approach beforehand.**

As a fender manufacturer with unparalleled expertise in rubber production, we at the ShibataFenderTeam Group consider creating and fostering product value as one of our most important goals. **Our mission is driven by our commitment to high-performance products and our clear sense of responsibility.**

References:
Unless indicated otherwise, all references to rubber and rubber compounding in this white paper are quoted from:
- Abts, G. (2007). Einführung in die Kautschuktechnologie *(Introduction to rubber technology)*. München: Hanser
- Hofmann, W. & Gupta, H. (2009). Handbuch der Kautschuktechnologie. Band 4 Artikelfertigung und Qualitätssicherung (Reference guide to rubber Technology. Volume 4 Production and Quality Assurance) Ratingen: Gupta

Note:

- **Testing guarantees that the performance of the final fender meets individual project requirements as well as international standards**
- **Establishing a detailed testing protocoll prior to testing is key, and it is highly recommended to consult with a trusted and reputable fender manufacturer**
- **A clear communication regarding correction factors and deviations is vital to ensure that the final fender is delivered as ordered by the client**

ShibataFenderTeam Group.

The ShibataFenderTeam Group is the leading international fender manufacturer with 50+ years of group experience in fender production, +120,000 fenders in service, and 90+ years of experience in the production of rubber products. Shibata Industrial, headquartered in Japan, is responsible for production and R&D, while ShibataFenderTeam, headquartered in Germany, handles design and sales. Their regional offices in the US, Europe, and Asia are supported by a large network of well-established local representatives on six continents. Creating and protecting value – this is the essence of what our products are meant to do. We offer the full range of marine fender products, from simple rubber profiles to highly engineered systems, as well as accessories and fixings. Engineering excellence means that our partners can be confident in expecting the best from us in all areas. Our experience has earned us a reputation as a dependable partner in the international port, harbor, and waterways market.

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