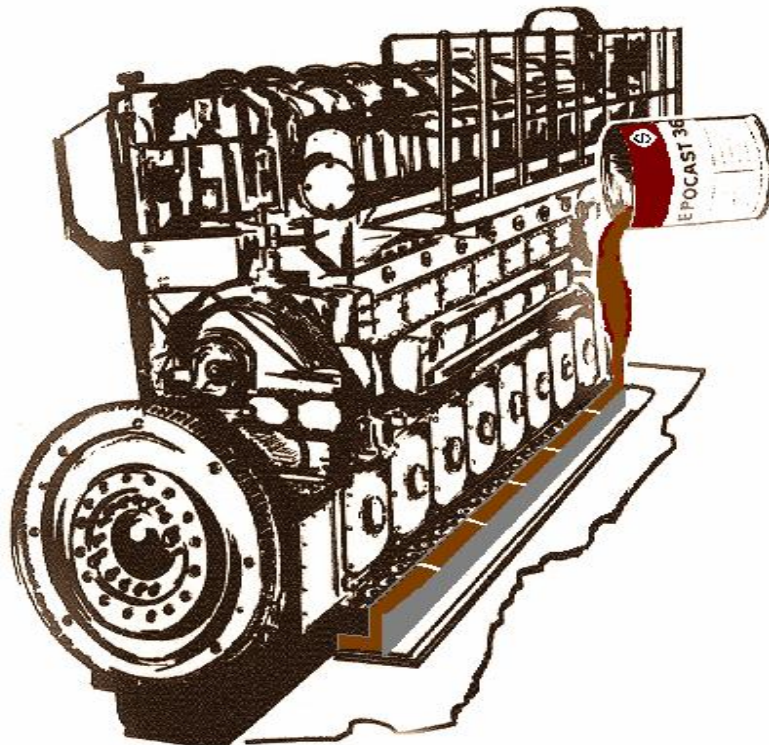


THE EPOCAST MARINE HANDBOOK

FOR SERVICE ENGINEERS & MACHINERY INSTALLATION DESIGNERS

1. THE EPOCAST EPOXY RESIN CHOCKING SYSTEM
2. MARINE APPLICATION
3. MARINE DESIGN INSTRUCTIONS
4. MARINE WORK SHEETS



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1.0. THE EPOCAST EPOXY RESIN CHOCKING SYSTEM

1.1. WHAT IS AN EPOXY RESIN CHOCK?

Metal chocks and shims have been used for many years to adjust the height and alignment of propulsion machinery. This requires skilled work and takes time. Epoxy resin chocks are used for the same purposes. They require less skill and less time to install, yet they perform better than iron chocks.

An epoxy resin chock is an engineering product which is cast-in-place to form permanent chocks for machinery support. It can be specified for chocking hot vibrating machinery, or critical alignment installation. A resin chock gives a better result for a longer period than a conventional iron chock. The basis of the success of resin chocks is the low modulus and near perfect cast-in-suit fit over a large surface area, combined with a high coefficient of friction and a high coefficient of thermal expansion. These together hold machinery securely, permanently, and without fretting or wear to the chock contact surfaces. Resin chocks are economical and convenient for newbuilding installation or for retrofits, due to the absence of any requirement for machining. Installation time is measured in days rather than in weeks normally required for iron chocking. It is used widely for marine main engines of any size, auxiliaries, steering gear, deck machinery and crane rails. Industrially it is used for generators, compressors, crushers and a wide range of grouting applications.

1.2. HOW LONG HAVE RESIN CHOCKS BEEN IN USE?

Epoxy resin chocks for mounting machinery have been used in shipyards around the world since the early 1970's in approximately 30,000 applications; proving the reliability and superior performance of resin chocks over traditional metal chocks. Many shipyards have experience with this system.

1.3. WHAT IS EPOCAST?

EPOCAST 36® is the registered trade name of the modern pourable epoxy resin chocking system developed and manufactured by H.A. SPRINGER GMBH, and distributed worldwide directly from our factory. As we are specializing in this business we are able to give good service at economical prices.

1.4. WHAT ARE THE BENEFITS OF USING EPOCAST 36® ?

There are several features or characteristics of **EPOCAST 36®** pourable chocking compound which differ from iron chocks. These give **EPOCAST 36®** a special 'behaviour' which gives tangible benefits.

FEATURES

- Low modulus of elasticity.
- Low modulus of rigidity.
- Low poissons ratio.
- High coefficient of thermal expansion.
- High coefficient of friction.
- Poured into place.
- Inert (does not corrode).
- Low exotherm (does not overheat when setting).
- Low volumetric shrinkage.

BEHAVIOUR

- Large surface contact area.
- Relatively uniform loading over the chock surface.
- The chock can bend with the bedplate in a seaway.
- Mechanical lock into surface irregularities.
- Accepts small relative movement between bedplate and foundation by distorting the chock.
- There is no fretting or pouring.
- As the engine warms up chock expands more than steel causing chock security to improve.
- Chock material attenuates the transmission of noise.
- Chock does not corrode.
- Can mix chocks in hot conditions.
- Can form large chocks in one pour.

Generally the SHIPOWER benefits from having machinery securely mounted on a system requiring minimum maintenance. The owner knows his machinery is not going to require rechocking during the normal service life of a ship.

The SHIPYARD knows it is economical and convenient to use resin chocks and that may owners now specify resin chocks in the light of operational experience.

The benefits are fully listed on the next page.

BENEFITS FROM GOOD RESIN CHOCKS

CHOCKS DO NOT FRET OR WEAR.
LESS RISK FROM NEGLECT OF BOLT TENSION IN SERVICE.
LESS LOOSE OR BROKEN BOLTS.
LESS FATIGUE FRACTURES OF PIPEWORK.
LESS NOISE TRANSMISSION AND LESS VIBRATION TO HULL.
NO MACHINING TO THE FOUNDATION.
NO MACHINING OR SKILLED HAND FITTING OF CHOCKS.
EASY QUALITY CONTROL.
WORK TAKES DAYS NOT WEEKS.
WORK TIME CAN BE ACCURATELY SCHEDULED.
SHORTER BUILDING PERIOD SAVES INTEREST CHARGES/PENALTIES.
APPROVED BY ALL CLASSIFICATION SOCIETIES.
ACCEPTED BY ALL MAJOR ENGINE BUILDERS.

SPECIAL BENEFITS FROM EPOCAST 36 RESIN CHOCKS

EPOCAST 36® IS STABLE WITH VIRTUALLY NO CREEP GIVING A PERMANENT INSTALLATION. **EPOCAST 36®** WAS THE FIRST RESIN CHOCK TO OBTAIN APPROVAL FOR USE UNDER HOT MEDIUM SPEED ENGINES WITH BEDPLATE TEMPERATURES UP TO 80°C.

EPOCAST 36® IS CAPABLE OF CASTING LARGE THICK CHOCKS IN ONE HOMOGENEOUS POUR. THIS SAVES HUNDREDS OF DOLLARS AND HOURS OF TIME. IT IS PREFERABLE TO FORM CHOCKS IN ONE POUR TO AVOID THE RISK OF CURLING OR DELAMINATION.

EPOCAST 36® MIXING AND POURING IS PARTICULARLY SIMPLE MAKING **EPOCAST 36®** THE IDEAL CHOCKING COMPOUND FOR APPLICATION BY SHIPYARD STAFF WHO HAVE BEEN TRAINED AND CERTIFICATED BY H.A. SPRINGER GMBH.

EPOCAST 36 CAN BE MIXED AT A HIGHER TEMPERATURE ALLOWING FAST MIXING, MINIMUM ENTRAPMENT OF AIR, AND PRECISE CONTROL OF THE INITIAL REACTION TO ENSURE GOOD QUALITY CHOCKS.

EPOCAST 36® WHEN MIXED AT THE CORRECT TEMPERATURE CAN GENERALLY BE Poured ONTO COLD STEEL. THIS AVOIDS DELAYS REQUIRED TO PREHEAT THE FOUNDATION AND AVOIDS THE RISK OF DISTURBING THE ALIGNMENT. IF POST CURE IS REQUIRED APPLY HEAT AFTER THE CHOCKS ARE Poured.

EPOCAST 36® CHOCK ARRANGEMENTS ARE APPROVED BY ENGINE MAKERS, AND CHECKED AND STANDARDIZED BY OUR OFFICE IN KIEL.

EPOCAST 36® TECHNICAL SERVICE IS AVAILABLE WORLDWIDE. THE SYSTEM ALLOWS TRAINED CERTIFICATED YARD STAFF TO DO THE INSTALLATIONS THEMSELVES.

1.5. WHAT IS H.A. SPRINGER-KIEL?

H.A. SPRINGER marine + industrie service GmbH is a wholly owned private limited company which develops, manufactures and markets special purpose products as required by customers. Our marine division has **EPOCAST 36®** and **EPOCAST D** for chocking; **EPOCAST 36-P** for cryogenic tank mountings and vertical grouting and **EPOCAST S** for socketing of wire ropes.

CELLOFLEX for external propeller shaft coatings.

Our industrial division has **EPOCAST 36®**, **EPOCAST G**, and **EPOCAST PI** for mounting stationary diesels and other plants **EPOCAST CR** for crane rail chocking. We have a policy of research into customer needs and technical solutions: "RESEARCH MAKES THE DIFFERENCE".

1.6. WHERE IS H.A. SPRINGER GMBH?

H.A. SPRINGER GMBH is in Kiel, a city in the north of Germany and on the Baltic coast. It is the gateway to Scandinavia and well placed for close contacts with European shipowners, many engine builders, including the two majors MAN-B&W and SULZER, and many Classification Societies.

1.7. HOW IS EPOCAST INSTALLED?

The principle is simple. The engine or machinery is aligned on wedges or jacking screws and the steel surfaces cleaned. Soft foam shuttering or damming is inserted to form the sides of the mould under the bedplate, metal damming is used to form the external side of the mould and to form a pouring space. Release agent is sprayed in, bolt holes are plugged.

The steel is generally not heated before pouring. THIS IS A UNIQUE FEATURE OF **EPOCAST** SAVING TIME AND REDUCING THE RISK OF MISALIGNMENT. The resin is warmed to the required temperature and the hardener added, the two are mixed for a short time and then poured into the mould. The chocks are left to cure for 24 to 48 hours. Sometimes heat is required to ensure a full cure. The correct cure is checked by monitoring the temperature of the setting reaction (exotherm) or by checking the Barcol hardness.

1.8. WHO SUPPLIES AND INSTALLS EPOCAST?

EPOCAST 36®, **EPOCAST D**, and ancillary materials are supplied by your local stockist or directly from H.A. SPRINGER GMBH. Our distributors, service facilities and representatives are in many ports around the world and the is still growing. Please ask for details of service in your area if you do not have this information.

EPOCAST chocks are usually installed by specialized sub-contractors or by the machinery installation department of a shipyard. Training courses for **EPOCAST** technicians are readily available in the shipyard, or at H.A. SPRINGER GMBH.

1.9. WHAT IS THE SHELF LIFE OF EPOCAST 36® ?

In excess of 18 months. We have found material several years old to be in perfect condition. There are no special storage requirements, except for a dry warehouse. If the **EPOCAST 36®** has been frozen the resin it should be warmed above 50 °C and premixed before use.

1.10. WHAT ARE THE OPERATING LIMITS OF EPOCAST CHOCKS?

For the marine industry, permanent total loading on **EPOCAST 36®** should be limited for accurate alignment of independently mounted machinery to 5 N/mm².

Temporary loading on **EPOCAST 36®** can be allowed up to 70 N/mm².

Medium speed engine bedplates can reach 80°C, and slow speed engine bedplates can reach 50°C. Resin chocks do not melt and they are considered fire proof. They will withstand overheating longer and better than the engine in the event of fire. **EPOCAST** will burn when exposed to flame but after about 3 minutes the exposed edges of the chocks form a burnt out heat shield, and further burning cannot take place. Technically they are classified as self extinguishing. The supporting surfaces of the chock are not exposed to the flame and are not damaged. The physical characteristics of **EPOCAST 36®** do not deteriorate at low temperatures and it does not become brittle. It has been tested to - 110 °C. **EPOCAST 36®** and **EPOCAST 36-P** are suitable for use in Artic conditions, and for supporting LNG tanks.

1.11. WHAT ARE THE LIMITS FOR CHOCK THICKNESS?

EPOCAST 36® chocks may be of any thickness.

- a. Chocks from 13 mm to 100 mm can easily be installed without difficulty by following simple mixing and pouring guide. THIS IS A UNIQUE FEATURE OF **EPOCAST** LEADING TO VERY SIMPLE INSTALLATION TECHNIQUES.
- b. Chocks below 13 mm thickness require experience. Consult your **EPOCAST** technician or H.A. SPRINGER GMBH.

1.12. DO WE NEED TO MAKE A TRIAL CHOCK BEFORE POURING?

No. A trial chock almost always ends in a failure because the heat sink in the model is not as great as the heat sink of the engine. The result is usually quite untypical of an onboard installation, and poor surface contact is a common result. A small test sample 100 x 100 x 40 mm or a small model chock, 200 x 200 x 40 mm, between 40 mm thick plates, will give good typical results. If you need a large trial sample, please consult H.A. SPRINGER GMBH for advice.

1.13. HOW DO WE FIT THE REAMER BOLTS?

Fit the reamer bolts before casting the chock. Spray the bolts with release agent and pour the chock.

1.14. ARE THERE SPECIAL REQUIREMENTS FOR THE HOLDING DOWN BOLTS?

Most engines in the past were secured by clamping the bed-plate to the foundation with short parallel shank bolts. Some fretting on metal chocks is inevitable and in recent years some engine builders have developed long waisted bolts to maintain bolt tension as the chocks fret and lose height.

The high coefficient of friction of resin chocks combined with the perfect cast-in-suit fit, increased contact area, and low modulus effectively eliminate fretting. This makes the use of long bolts unnecessary and short bolts are well proven on resin chocks, and most Classification Societies accept them. There is no evidence of trouble with long or short bolts provided they are stressed above 50 N/mm². The yield stress of the bolt material is above 600 N/mm².

There is an argument in favour of long bolts because long bolts allow more stretch or a lower tension to achieve a given stretch (GL requires minimum 0.172 mm stretch) at 5,0 N/mm² total load. Our design instructions cover these requirements.

1.15. HOW DO WE ADJUST ALIGNMENT AFTER POURING?

Chocking should be carried out afloat so no adjustment is needed. This is a fact many customers find difficult to accept, but after the first installation they are satisfied it is true. In the case of damage (e.g. through grounding) the chocks can be removed, just as you would remove an iron chock, and temporarily shimmed or ground just as iron.

1.16 IS EPOCAST FLEXIBLE?

Yes, if you take a bar of **EPOCAST** 1000 mm long, by 75 x 40 and support the ends on two blocks, two men can stand in the centre and it will bend more than 10 mm. This is more than enough to satisfy normal application requirements.

1.17. WHAT IS THE LIFE OF RESIN CHOCKS?

EPOCAST 36® is made from petrochemical based material, in which the molecules link together to form a hard shock resistant and stable solid. During the first hours of cure, especially in cold conditions, the molecular bonding is at a low level and the chock is brittle and unstable. With the application of heat and time the molecular bonding increases so that long before sea trials the chock is at full strength being shock resistant and stable. There is no deterioration through age, and your chocks will literally go from strength to strength for the life of the installation.

1.18. IS IT DIFFICULT TO LEARN HOW TO USE EPOCAST?

The instruction book appears formidable, but in fact it contains simple step by step instructions which become easy to remember after the first hands on experience. Customers usually use the first installations for training by our staff. After that a certificate can be issued to qualified

staff to enable work to be carried out with SPRINGER GMBH supervision. Generally there are less decisions for the machinery outfit staff to make on the job. For example, for small units and normal medium speed engine installations always use all the hardener. There is seldom a need to pour in layers, consult H.A. SPRINGER GMBH before doing so.

1.19. HOW DO WE DESIGN AN EPOCAST INSTALLATION?

The principle is simple. Make the chocks large enough to keep the pressure on the chock within limits (max. 0,7 N/mm²). Design the bolt tension to satisfy Class requirements. Check that clamping force and friction is enough to withstand thrust or fit end stoppers. We offer a full technical service in Kiel, and chock application drawings are readily available

from our office. We can also apply for any necessary approvals from Classification Societies, machinery manufacturers and ship-owners. We have made the calculations and prepared drawings for most equipment available.

1.20. IS THERE A GUARANTEE?

Please have a look into our general terms and conditions

1.21. HOW DO WE ORDER EPOCAST 36® ?

Please write, telephone, or telefax to H.A. SPRINGER GMBH, KIEL, or any authorized distributor giving details of machinery type, chock thickness and Class. We will then submit our offer. **EPOCAST 36®** is packed in the industry standard for propulsion chocking reasons of 2.0, 4.0 or 8.0 litre units of pre-measured resin and hardener. You are buying volume not weight, but these packs are sometimes referred to as 3.2 kg, 6.4 and 12.8 kg units, and in the imperial system 122 cu.in., 244 cu.in., 488 cu.in. and 7.06 lbs., 14.12 lbs. and 28.24 lbs. Generally you can compare the prices of single or double units, unit for unit, without any need to adjust for any different packing volumes.

Some manufacturers pack their deck machinery grade resins in 3 litre and 6 litre units. In this case you need to compare litre or cubic inch prices. (if you compare kg or lbs. prices you could have wrong quantities due to different densities. You buy chocks by volume not weight.)

**EPOCAST STOCKS ARE HELD IN MOST MAJOR PORTS AND CAN ALSO BE
QUICKLY FLOWN FROM KIEL.**

2.0. MARINE APPLICATION INSTRUCTIONS

INTRODUCTION. These instructions may appear complicated. They are in fact very simple if you follow them step by step. After the first job you will find just how easy they are. H.A. SPRINGER GMBH or our agent can help you with your installation work and will be pleased to offer training in your yard or at our headquarters in Kiel.

Plan approval for the chocking arrangement is usually required by the Classification Society before work starts. Make sure a plan has been submitted and approved.

In the case of MAN B&W MC/MCE engines a MAN B&W drilling tool is required to drill the holding down bolt holes in the foundation. Alternatively drill the holes accurately before placing the engine.

2.1. EPOCAST CHOCKING MATERIALS REQUIRED

2.1.1. H.A. SPRINGER GMBH SUPPLY

- a. **EPOCAST 36®** (main engine grade resin brown colour) in sufficient quantity to pour the total volume of chocks, including extra material for overpour and wastage. A unit comprises one can of resin and a bottle of hardener. Allow extra material 20% for deck machinery and medium speed engines. Allow 10% for slow speed engines.
- b. **EPOCAST D** (auxiliary grade resin green colour) of sufficient quantity to pour total volume of chocks including extra material for overpour and wastage. Allow extra material 20% for deck machinery.

A small unit of **EPOCAST** contains 2000 cc, a middle unit contains 4000 cc and a large unit contains 8000 cc. The effective area of **EPOCAST** (A) in cm² should be noted on your working drawing. Multiply this by the thickness (t) in cm, allow for overpour (1.10 or 1.20) and divide by unit volume (2000 cc, 4000 cc or 8000 cc) to obtain the number of units required.

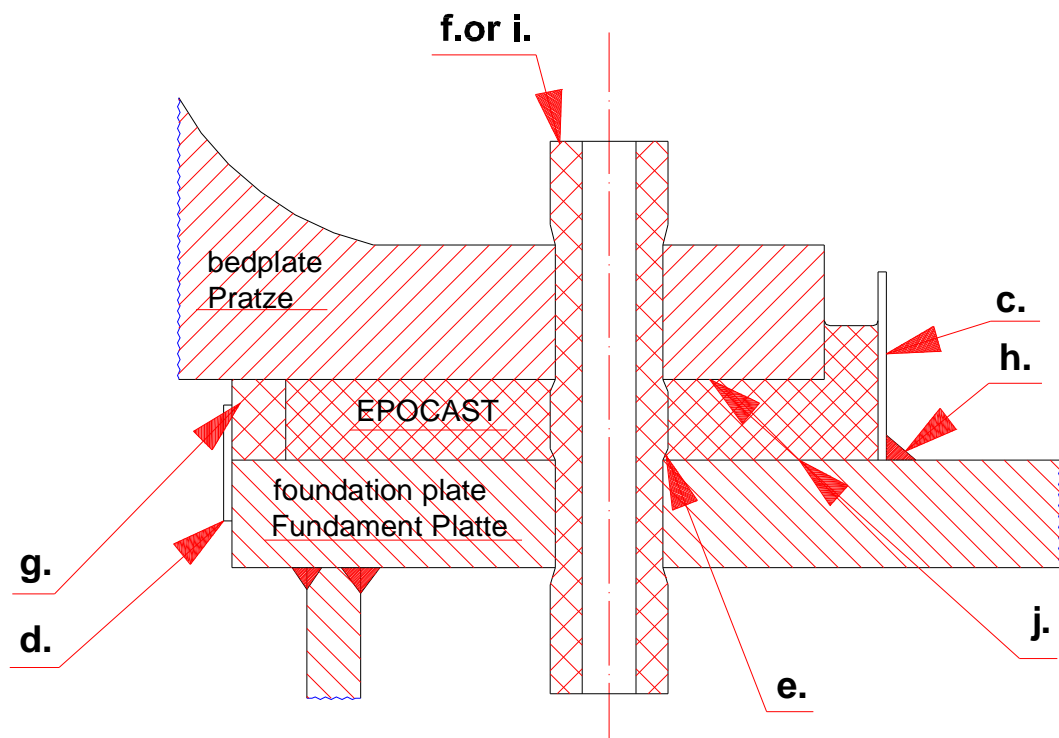
$$\text{Quantity required} = \frac{A \times t \times (1.10 \text{ or } 1.20)}{2000, 4000 \text{ or } 8000} = \text{units}$$

2.1.2. CONSUMABLE DAMMING MATERIALS, YARD SUPPLY.

- c. Metal front dams, 3 to 6 mm thick x (chock height + 40 to 60 mm)
- d. Metal rear stopper flat bar.
- e. High melting point grease.
- f. Foam plugs to close the bolt holes if required.

2.1.3. CONSUMABLE DAMMING MATERIALS, H.A. SPRINGER GMBH SUPPLY.

- g. Foam damming, 50 x 20 mm or 70 x 25 mm (or other dimensions on request)
- h. Sealing compound.
- i. Soft sleeve for jackscrew and bolt holes.
- j. Release agent (CFC - FREE).



2.1.4. TOOLS, YARD SUPPLY.

- k. Slitting knife and/or scissors.
- l. Torch/flash lamp and wandering lights.
- m. Eye shields or goggles.
- n. Protective gloves.
- o. Rags and suitable solvent for cleaning mixer blade and spillage.

2.1.5. TOOLS, H.A. SPRINGER GMBH OR YARD SUPPLY.

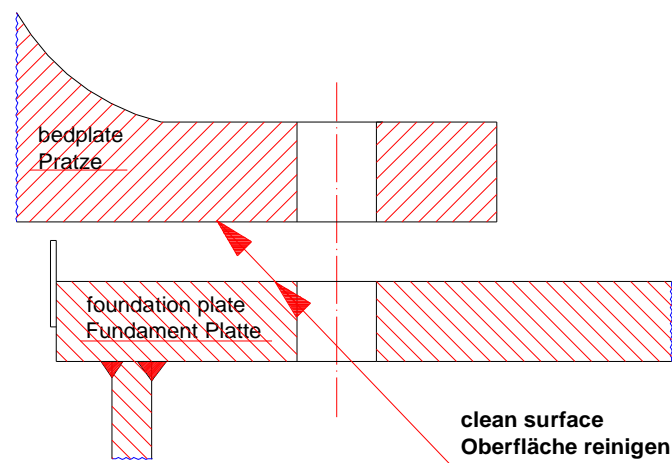
- p. Heavy duty electric hand drill with a recommended constant operating speed up to 1000 rpm.
- q. Mixing blade and spares.
- r. Surface contact thermometer.
- s. When necessary sufficient heaters to ensure that plate temperature in the chocking area is maintained at not less than 20°C. Allow 1 kW/meter of bedplate/side. The **EPOCAST** 2 kW strip heater is most suitable.
- t. Barcol Tester for measuring hardness (cure) of **EPOCAST**.
- u. Thermocouple read out to monitor exotherm. (Optional)

2.2. PROCEDURE

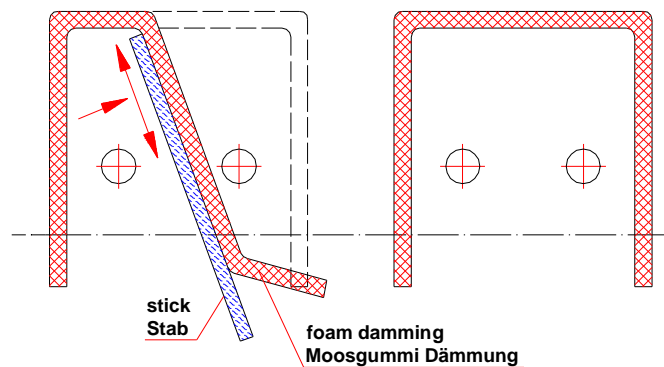
2.2.1. The chocks may compress 0.001 times the chock height when the holding down bolts are tightened, e.g. 40 mm chock thickness may compress 0.04 mm. Align close to the top of the allowed coupling tolerance and obtain satisfactory alignment and crankshaft deflections. Check deflections after the job is finished when temperatures have returned to ambient.

2.2.2. Prepare the resin to the required temperature well ahead of time. (See our MIXING and POURING GUIDE 2.3.2). The temperature of the pouring should never be less than 25°C at the time of mixing, so heat in most of the countries is required. The hardener should be at ambient temperature. A convenient method of heating is to place **EPOCAST** in a small room or container with hot air circulation. Alternatively for large jobs or where the resin has not been conditioned a quick method is to place the cans for a few minutes on two **EPOCAST** heaters. Check the mixed temperature is within +/- 5°C of the required temperature. In hot climates avoid leaving **EPOCAST** in direct sunlight before use as the temperature may be higher as recommended. The mixing temperature in the method is controlling the speed and heat generation of the setting process. Therefore **EPOCAST** for small thin chocks should be at a higher temperature than for large thick chocks. If for any reason you believe the resin has been stored at temperatures well below 0°C, heat up the resin to 50°C (storage for a prolonged period at room temperature (20°C) is not sufficient) and mix the resin only. Then let it cool back to the required temperature for use. The hardener should be warmed to room temperature around 20°C and not to 50°C.

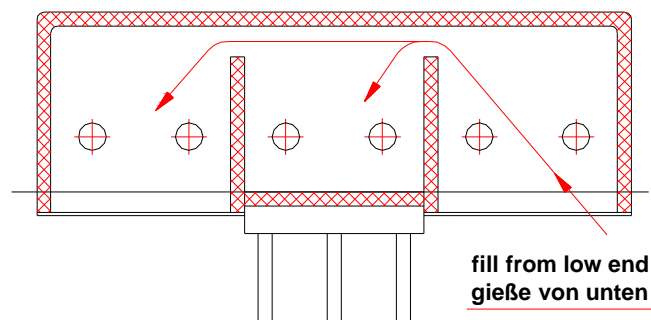
- 2.2.3.** Finish all hot work (welding) on foundation. If possible tack weld a stopper (2.1.2.d.) to the back edge of the foundation to facilitate installation of foam damming.
- 2.2.4.** All holes should be drilled and holding down bolts available but not inserted. Closed cell plastic foam plugs should be available to fill bolt holes if required. Where applicable fitted bolts should be driven in. Fit the reamer bolts before casting the chock, spray with release agent and pour the chock around the bolt.
- 2.2.5.** Check all materials are available. Check ship trim. It is preferable to obtain a down aft trim and to fill the moulds from the lower (aft) end. If there is a steep trim keep the chock length to a minimum.
- 2.2.6.** Clean the foundation and bedplate surfaces where chocks are to be poured. Remove all grease, oil, mill scale, rust or paint. A very thin coat of epoxy shot primer (20-25 um) is acceptable for main engine foundations, but check carefully it is original thin primer, not a covering of thick paint. For deck machinery a thin coat of inorganic zinc or similar is acceptable to prevent corrosion.



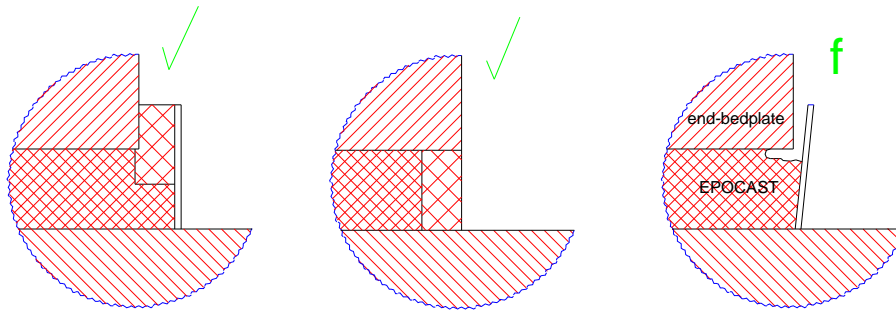
- 2.2.7. Flexible damming is inserted between the bedplate and foundation to form liquid tight sides for the moulds or dams. Make sure the damming is firmly in place, and cannot collapse or leak. The **EPOCAST** exerts a surprisingly strong pressure on the lower edge of the damming. So take extra care when forming dams.



- 2.2.8. To avoid stress which may lead to cracked chocks, grind off or apply putty, mastic or self adhesive foam rubber strips to sharp edges of steps and fixed top liners. Chock length should be short, ideally containing only two bolts in a row or four in a rectangle. The length should not exceed 750 mm if possible. If the bolts are more than 300 mm apart, insert foam dividers midway between the bolts to keep chock length short. If there is a steep trim, the chocks have to be short or the **EPOCAST** will run over the top of the lower end of the steel front dam. If the overpour is blocked by the side chock then fill from the next chock as shown in the sketch.

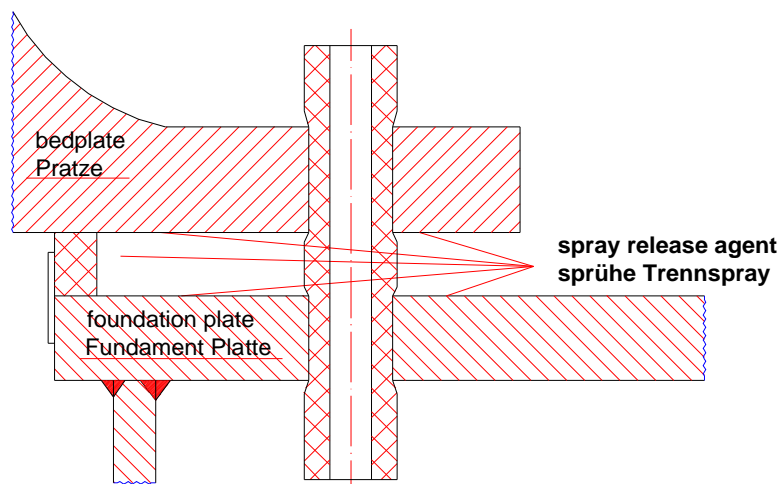


- 2.2.9.** Fix foam damming on the end of the bedplate or under the bedplate. Do not fix metal front damming plate at the end; you will get cracks or voids.

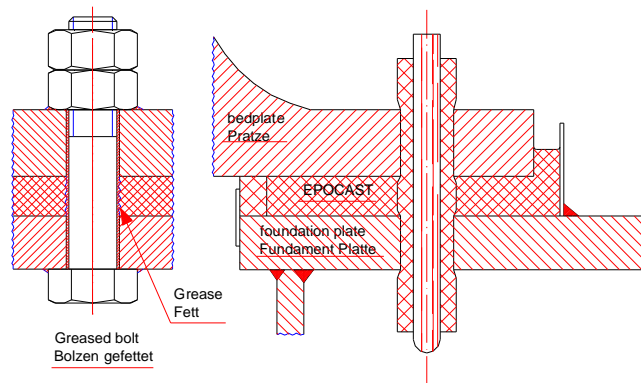


- 2.2.10** Jacking screws and fitted bolts inside thick chocks should be sleeved with soft closed cell plastic foam tube. Do not use damming sponge as this allows air to enter. Jacking screws and fitted bolts in chocks under 50 mm thick can be greased, but take care not to spread grease on the bedplate or foundation.

- 2.2.11.** Spray release agent lightly on all surfaces that will be in contact with the **EPOCAST**. Do not apply grease.



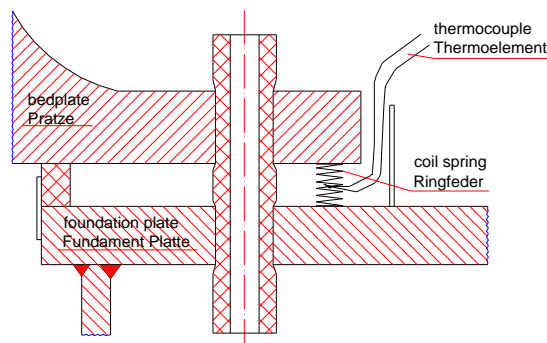
- 2.2.12.** For generators, deck machinery and small units you may apply a thick coating of thick high melting point grease to the holding down bolts before inserting them. These bolts should only be hand tight. If chock thickness exceeds 50 mm then follow instructions for larger units in the next paragraphs. Where possible use foam plugs in preference to wood plugs or bolts.
- For LARGER ENGINES and gear boxes, use GREASED FOAM PLUGS. Armaflex pipe insulation is ideal. Choose Armaflex tube the exact outer diameter as the bolt hole and insert the tube. Then insert an oversize wood dowel to expand the tube to give a tight fit.



2.2.13. LLOYD'S REGISTER TEST REQUIREMENT FOR EPOCAST 36 FOR LOADING CONDITIONS ABOVE 3,5 N/mm²

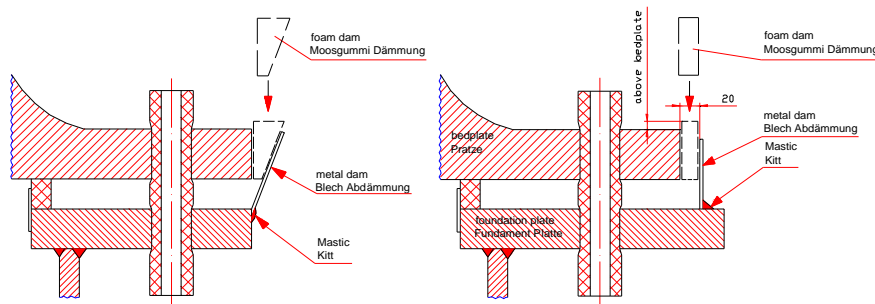
With the monitoring of exotherm temperatures crushing tests from **EPOCAST 36®** samples are not anymore necessary. Instead Lloyd's Register require a minimum exotherm temperature of 40 °C to be measured inside of the chock.

Locate thermo couples in the centre of the thinnest and thickest chock if applicable. A small coil spring makes a good support.



In case 40 °C exotherm temperature cannot be attained (thin chocks or cold steel mass in wintertime) external heat to the chock in the unloaded condition is required to achieve a minimum temperature of 40 °C for at least 16 hours. To get a good post cure for attaining the 40 °C we would suggest to use small electric heaters (2000 W), heating lamps or hot air blowers. Bring the heaters close to the chocks and cover them and bedplate with a heat insulation blanket (glass cloth) to increase the efficiency of the heaters. Monitor the temperature with the same thermo couple you have used for measuring the exotherm.

- 2.2.14.** Tack weld front metal dams in place so the pouring opening is 20 to 30 mm wide and the top of the dam is approximately 40-60 mm above the underside of the bedplate. Seal the lower edge of the metal dam with sealing compound. Apply release agent to the inside of the front metal dam and to the edge of the bedplate. If the bedplate is rough, apply a thin smear of grease to the vertical edge of the bedplate.



- 2.2.15.** Take care to protect drain holes and to keep **EPOCAST** from unwanted places such as side chocks. This is best done by greasing a piece of foam damming and placing as a “plug”. Foam damming is normally left in place, but where it has to be removed grease the inside surface. This will enable it to be removed later.

- 2.2.16.** Check and record crankshaft deflections. Ideally these should be open at piston top dead centre indicating a “sag” in the crankshaft. This will tend to straighten when the engine heats up (The upper part of the engine will expand more freely than the lower part). Also check and record shaft coupling readings.

- 2.2.17.** When necessary set up heaters in the chocking area to maintain plate temperature above 20°C. Do not turn on the heaters. After resin has been poured and has solidified, turn on heaters. When using **EPOCAST** electric heaters, lay them on the foundation 100 mm away from the side of the chocks.
- 2.2.18.** For sub-zero conditions see section 2.6.

2.3. MIXING AND POURING

2.3.1. These instructions are for **EPOCAST 36®** and **EPOCAST D**.

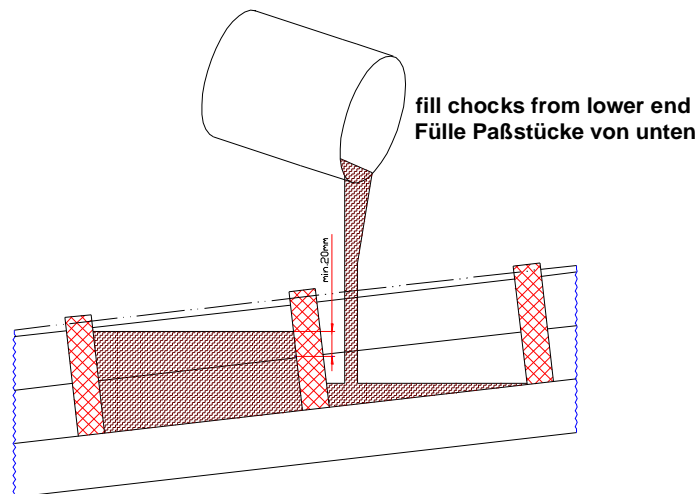
2.3.2. Follow the MIXING & POURING GUIDE 2.3.2. step by step:

- 1.** Find the chock thickness on the left side of the chart, draw a horizontal line across the chart, line "H".
- 2.** Find the steel plate temperature along the top of the chart and draw a vertical line down the chart to the very bottom of the page, line "V".
- 3.** The line "H" and "V" will "cross". Look to the left side again and read "A", "B" or "C". Go to the foot of the chart and find the same "A", "B" or "C", and look along that row until you meet the vertical line "V" you drew earlier. Bring the resin to this temperature, add hardener and mix.

* Or in special cases as recommended by H.A. Springer.

- 2.3.3.** Chocks are almost never poured in layers; please contact H.A. SPRINGER GMBH or your local representative for more information before starting work on chocks less than 13 mm thick or more than 70 mm thick. Do not use steel filler plates or round steel filler bars in chocks without consulting H.A. SPRINGER GMBH as this is a technique generally to be avoided.
- 2.3.4.** All damming work must be completed before starting to mix **EPOCAST** and hardener.
- 2.3.5.** Use eye shield and protective gloves.
- 2.3.6.** Check that **EPOCAST 36®** is heated to the required temperature right through the can or that the average temperature of the contents is correct.
For large jobs or where the resin has not been conditioned, a quick method is to place the cans for a few minutes on two **EPOCAST** heaters. Check the mixed temperature is within +/- 5°C of the required temperature.
- 2.3.7.** Remove the lid from the can of resin and add hardener.
- 2.3.8.** Hold the can so it cannot spin. Power mix up to 1000 rpm for 1 to 2 minutes using correct mixing blade to ensure homogenous mix. Traverse side and bottom of the can to ensure complete mixing of all resin and hardener. Keep the mixing blade on the bottom of the can. Do not let it race (speed up).
Do not draw air into the mix. Check visually that all hardener has been drawn down from the surface and has disappeared into the mix. If the resin becomes light in colour you are racing the blade at more than 1000 rpm and lifting it off the bottom of the can. This draws in fine bubbles of air.

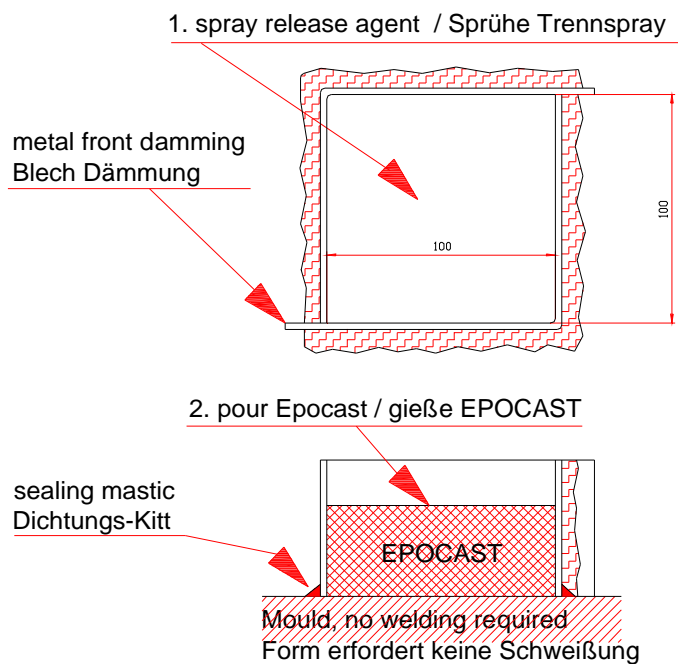
- 2.3.9.** Shortly after mixing, pour each unit in a thin stream into the lower (aft) end of the chock only. If necessary use a small pouring tray to guide the **EPOCAST** into the mould. Do not scrape residue from the side of the can as this may not have been well mixed.
- In summer conditions with thick chocks, fill the chocks in a chequer board pattern, missing alternate chocks. Then go back and pour the remaining chocks after the first ones have set and cooled, generally 2 to 3 hours after pouring.



- 2.3.10.** Until the resin sets keep a careful watch for leaks. During setting **EPOCAST** will be drawn into the chock from the overpour. Where chocks are large this reservoir may need to be refilled during the setting. **KEEP A CAREFUL WATCH.** After the **EPOCAST** has hardened the overpour may look untidy. Pour a thin layer of **EPOCAST** over this to improve the appearance. Then apply required heat and allow recommended time for a proper cure.

2.4. TEST PIECE

- 2.4.1.** If test pieces are required, construct the moulds from surplus metal front damming, making a box 100 x 100 with no bottom. Place this on a clean area of foundation plate near the foundation chocks, using mastic around the base. Spray with release agent.
- 2.4.2.** Pour the resin directly onto the ship's foundation to make a chock 40 mm thick. This ensures a proper cure and adequate heat sink to produce a fair sample. The material batch number should be recorded for each sample. The test piece should be left to cure along side the chocks. It has reached minimum acceptable cure when the Barcol Hardness reading on the underside of the test piece exceeds 40 Barcol. The test piece may not always reach proper cure as it is smaller than the main chocks. The purpose of a test piece is to verify the quality of the material. Therefore it is permissible to cure the test piece for 1 hour at 40 °C before testing to ensure it has been fully cured.



2.5. AFTER POURING

2.5.1. In general, with steel temperatures as detailed below, and with **no application of external heat**, the cure of the resin may occur after the time indicated in the table

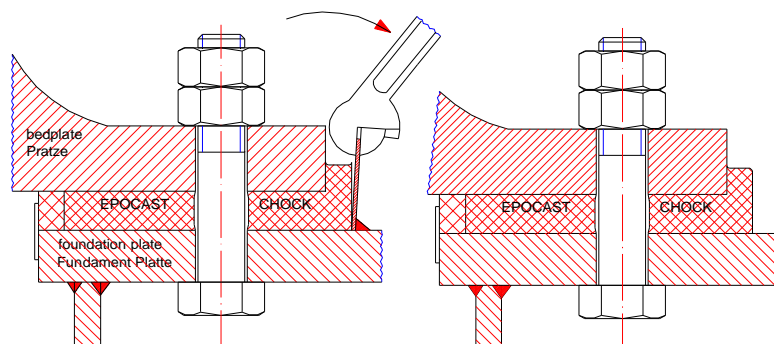
Steel Temperature	< 13°C	No cure
	14°C - 17°C	48 hours
	18°C - 20°C	36 hours

2.5.2. LLOYD'S REGISTER REQUIREMENT FOR LOADING CONDITIONS OF 3,5 N/mm² AND BELOW

For steel temperatures below 15 °C the following procedure is to be carried out:

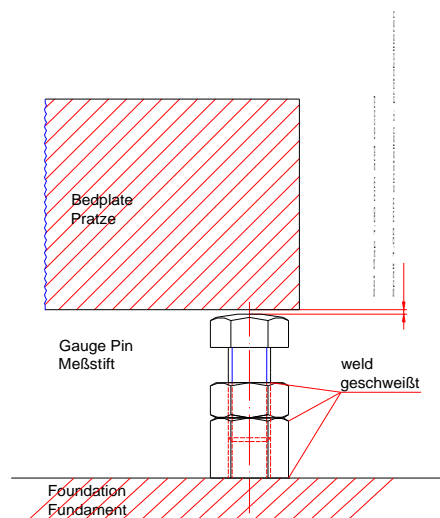
- Switch on heaters and bring them close to the chocks.
- The heaters and bedplate can be covered with a heat insulating blanket to increase the efficiency of the heaters to shorten the curing time.
- Maintain the chock temperature at 25 °C or higher for at least 24 hours or more, until a Barcol hardness reading of 40 is achieved on the sides of each chock.
- The temperature (25 °C minimum) should be measured on the surface of the accessible parts of the chock.

2.5.3. After full cure remove the heaters. Remove the wedges or back off the jacking screws. When the weight of the engine is on the chocks then remove the metal front damming plate and pull it away from the **EPOCAST**. Do not use a hammer as this might accidentally break off the overpour and spoil the appearance of the job.



2.5.4. Remove the bolt plugs and insert the bolts. Ensure the chocks cool to ambient temperature before tightening the holding down bolts in accordance with instructions.

- 2.5.5.** For critical alignment applications, check with a Barcol Impressor that Hardness reading on the side of the chocks exceeds 40 before tightening the holding down bolts. Take readings from each chock and record.
- 2.5.6.** Tighten the holding down bolts. A calibrated torque wrench, hydraulic bolt stretcher, or measured stretch should be used for critical alignment installations.
- 2.5.7.** Check crankshaft deflections and record. Check coupling alignment and record. (Note that temperature conditions must be identical at each reading or distortions due to thermal growth occur. Where there is strong sun measure at night or early morning, at the same time for each reading).
- 2.5.8.** Fix **EPOCAST 36®** name plate on the engine to indicate it is on resin chocks and to specify the bolt tension or torque (supplied by H.A. SPRINGER GMBH).
- 2.5.9.** Fix measuring pins between the foundation and bedplate away from jacking screws or holding down bolts if required. Record the gap and enter on the record card.



- 2.5.10.** Please keep the machinery installation record card 2.7.0. for your own records and return the simple job report postcard to H.A. SPRINGER GMBH, thank you.

2.6. EPOCAST APPLICATION IN SUB-ZERO CONDITIONS

- 2.6.1.** In cold conditions there are two basic situations, non-critical alignment of deck machinery and critical alignment of engine room machinery. Like most other shipyard operations, winter working requires special preparations, but it is neither technically difficult nor costly.
- 2.6.2.** Work on deck. The particular hazard here is cold wind. The basic needs are to erect a wind break so the **EPOCAST** will pour accurately and not be blown all over the deck and to heat the **EPOCAST**.
- 2.6.3.** A wind break is essential, a light wood and plastic sheet hut placed over the deck machinery by the crane, is best. Some yards have built more durable shelters for deck machinery work out of corrugated semi-transparent plastic or fiberglass sheeting.
- 2.6.4.** Use a large flexible fabric hose for piping in hot air from portable space heaters or use electric **EPOCAST** heaters placed close to the foundation and bedplate to warm the steel surfaces.
- 2.6.5.** The **EPOCAST** should be warmed in accordance with our POURING and MIXING GUIDE 2.3.2.. Mix in a sheltered place, place the cans on a piece of cardboard packing to prevent heat loss whilst mixing, and then pour immediately. It will cool back when exposed to cold during pouring.
- 2.6.6.** After pouring, maintain the steel and **EPOCAST** at a minimum of 25°C or more for 24 hours. (Warm sunny days and time will add to the cure. We have increased the recommended cure temperature to 25°C to give a wider safety margin for very cold conditions. In winter temperatures can drop unexpectedly at night, which is often the time **EPOCAST** is poured).
- 2.6.7.** Work below deck. In this situation we do not have any exposure to cold wind, but the engine room is often open or too big to warm up. Therefore leave the steel foundation cold.

- 2.6.8.** The **EPOCAST** should be warmed up according to the MIXING & POURING GUIDE 2.3.2. Place the cans on a piece of cardboard packing to prevent heat loss whilst mixing and then pour. The **EPOCAST** will cool back when exposed to cold during pouring.
- 2.6.9.** As soon as **EPOCAST** get sticky, switch on heaters and bring them close to the chocks.
The heaters and bedplate can be covered with a heat insulating blanket to increase the efficiency of the heaters to shorten the curing time. Maintain the chock temperature at 25°C or more for a minimum of 24 hours, or 48 hours if time permits to achieve a minimum hardness of 40 Barcol. Please note: Lloyds Register requires a minimum temperature of 40 °C for the post cure. (See item 2.2.13).
- 2.6.10.** Continue as detailed in section 2.5.0.

2.7.0 EPOCAST JOB RECORD CARD

COMM.-NO. :

Prepared by Ausgeföhrt durch	
Date Datum	
H.A. Springer Identity Card No. Ausweis Nr.	
Ship / Newbuilding No. Schiff / Neubaunummer	
Owner Eigner / Reederei	
Yard Werft	
Type of machinery Anlagentyp	
Arrangement prepared by Unterlagen erstellt durch	
Drawing Number Zeichnungsnummer	
Classification Society Klassifikationsgesellschaft	
Batch No. of EPOCAST 36® resin Chargennummer EPOCAST 36® Harz	
Batch No. of EPOCAST 36® hardener Chargennummer EPOCAST 36® Härter	
Chock thickness (mm) Paßstückhöhe	
Ambient temperature (°C) Umgebungslufttemperatur	
Foundation temperature (°C) Fundamenttemperatur	
Exotherm temperature (°C) Exotherme Reaktionstemperatur	
Finish of pouring Ende der Vergußarbeiten	Date / time Datum / Uhrzeit
Using of heaters Nachheizen	Yes / no Ja / Nein

1. BARCOL HARDNESS TEST (PORT SIDE)

Ergebnis Barcol Test (Bb.-Seite)

Chock No. / Paßstück Nr.									
01:	02:	03:	04:	05:	06:	07:	08:	09:	10:
11:	12:	13:	14:	15:	16:	17:	18:	19:	20:
21:	22:	23:	24:	25:	26:	27:	28:	29:	30:
31:	32:								

PORT SIDE / Bb.-Seite 1 --- n

STB.-SIDE / Stb.-Seite 1 --- n

2. BARCOL HARDNESS TEST (STB.-SIDE)

Ergebnis Barcol Test (Stb.-Seite)

Chock No. / Paßstück Nr.									
01:	02:	03:	04:	05:	06:	07:	08:	09:	10:
11:	12:	13:	14:	15:	16:	17:	18:	19:	20:
21:	22:	23:	24:	25:	26:	27:	28:	29:	30:
31:	32:								

Date / Datum

Signature / Unterschrift

Approved / Genehmigt

2.7.1 EPOCAST INSTALLATION RECORD CARD (Part two)

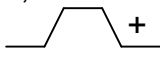
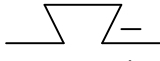
Crankshaft deflection before pouring
Kurbelwellenatmung vor dem Verguß

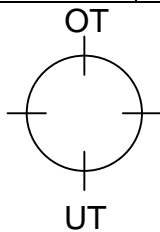
Engine Temperature(°C):

Maschinen Temperatur (°C):

Date :

Datum

Reading Anzeige 0,01 mm	clock	1	2	3	4	5	6	7	8	9	10	11	12
	OT												
90													
	UT												
enter : +/- bestätige mit : +/-	270												
	OT												



Enter chock thickness (t) : mm
Align engine high by $t \times 0,001$: mm
Coupling aligned high(T-B) / 2 : mm

Crankshaft deflection after tighten the holding down bolts

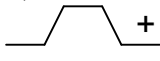
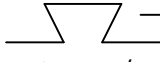
Kurbelwellenatmung nach dem Anziehen der Fundamentschrauben

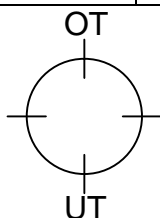
Engine Temperature(°C):

Maschinen Temperatur (°C):

Date :

Datum

Reading Anzeige 0,01 mm	clock	1	2	3	4	5	6	7	8	9	10	11	12
	OT												
90													
	UT												
enter : +/- bestätige mit : +/-	270												
	OT												

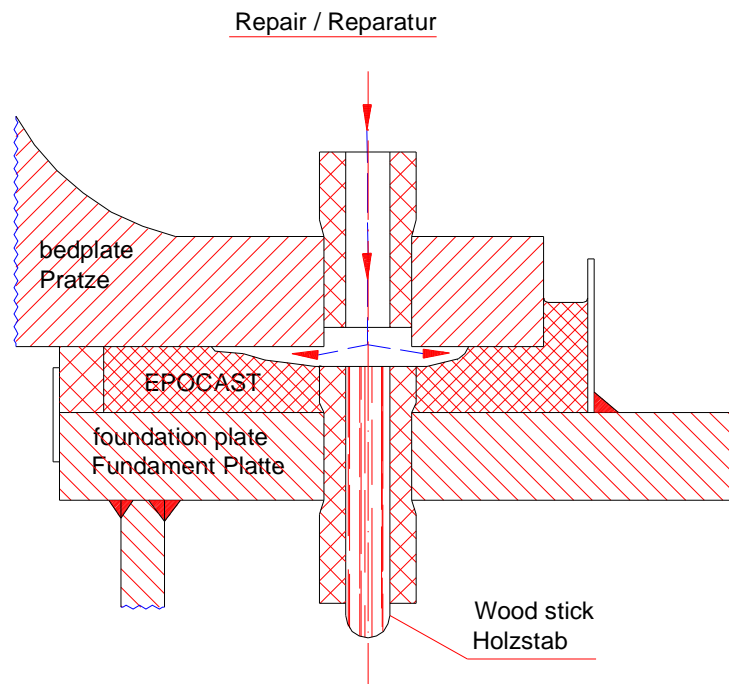


Alignment before tightening the holding down bolts(T-B) / 2 : mm
Alignment after tightening the holding down bolts (T-B) / 2 : mm

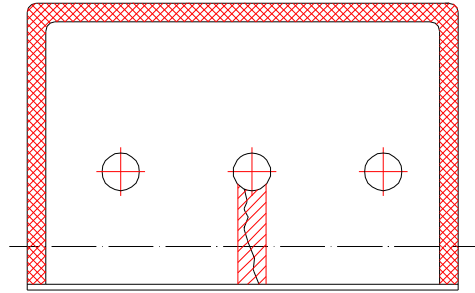
2.8 REPAIRS OF FAULTY CHOCKS

2.8.1. The time may come when through some error your installation of **EPOCAST** is less than perfect and some repairs may even be necessary. The most common problem is a void in the top of the chock due to leaking. **EPOCAST 36®** can be "injected" into this void by plugging the bolt hole and pouring in **EPOCAST 36®** with full hardener at with a hydrostatic head of at least 300 mm. This is normally acceptable to the surveyor and owner in the case of one or two chocks.

If many of the chocks are faulty, it is better to remove them all and start again.



- 2.8.2.** Sometimes a vertical crack occurs running into the bolt hole. This can be left, but for aesthetic reasons it is usual to grind out the crack to about 30 mm and pour in new **EPOCAST 36®** to repair the crack.



cut out - repour
heraus schleifen - wieder vergießen

- 2.8.3.** When the corners of the overpour are broken for any reasons, (usually heavy handed removal of the front damming) there is no need for repair.
- 2.8.4.** If the Barcol Hardness does not reach 40 when expected to then take a piece of **EPOCAST 36®**, either the sample or a piece of overpour, and cure it for 1 hour at 40°C. Let it cool, then check the hardness. It will now exceed 40. This proves the mix is correct, simply add heat and time to get a proper cure. You can start the engine circulating system to add extra heat.

3.0. MARINE DESIGN INSTRUCTIONS

3.1. H.A. SPRINGER GMBH maintains a full technical service and all application drawings are readily available from our office in Kiel. We can also apply for any necessary approvals from Classification Societies and machinery manufacturers.

The **EPOCAST 36®** system of pourable chocks or grout may be used for mounting all sizes and types of main and auxiliary machinery, provided attention is paid to the design parameters regarding chock loading and chock temperature.

A resin chock is a compression load bearing material. Because of its low viscosity and low surface tension, the liquid resin will precisely conform to any reasonable irregularity in the chocking surface, and fill completely the designed chocking space in individual chocks or continuous grout as required.

3.2. TWO MARINE GRADES ARE USED

EPOCAST 36®

MAIN ENGINE GRADE offers high physical properties. It should be specified for precise alignment, high continuous operating temperatures up to 80°C and high shock applications.

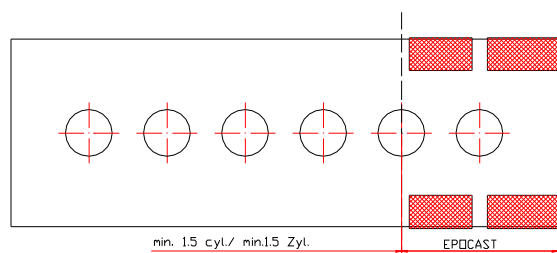
EPOCAST D

AUXILIARY GRADE is a lower cost material which should be specified for all general chocking arrangements, e.g. auxiliary equipment on a common bedplate, hull pads and heavy industrial machinery for continuous operating temperatures up to 60°C. It is also used as a free flowing general purpose industrial grout under cold machinery, presses, etc.

EPOCAST is packed in units of 2000 cc, 4000 cc and 8000 cc. A unit is a can of resin and a plastic bottle of hardener, pre-measured. To use, mix one bottle of hardener into one can of resin.

The quantity of resin required is the volume of the chock plus approximately 20% for overpour (10% for large slow speed engines).

- 3.3.** There is no minimum or maximum limit to form a chock of any thickness, but in order to obtain ease of application and good in service performance use these guidelines. 35 mm is the minimum convenient and economical chock thickness for which to design propulsion chocks, 70 mm is a convenient design maximum, we recommend 45 mm. Auxiliaries and deck machinery chocks can be designed 20 mm thick, we recommend 25 mm. Where chocks have to be 20 mm or less, cure at 20°C. Where chocks have to be over 70 mm thick consult H.A. SPRINGER GMBH, Kiel, or an approved **EPOCAST** technician.
- 3.4.** In some cases the bedplates are formed with hollow castings. These can be filled with an inert compound to produce a level bedplate for easier damming. If they are not filled, more material is required as it rises into the hollow. This also makes it necessary to break the chocks in the unlikely case of removal. Note the effective area is reduced by the void spaces. In view of the above problems, manufacturers are now making solid bedplates, and where hollow bedplates are encountered it is sometimes better to use metal chocks.
- 3.5.** When there is not enough surface area because of the hollow foundations or small mounting feet, the area can be increased by holding an oversize machined steel plate up to the underside of the bedplate. The **EPOCAST** is then poured into the space between the plate and foundation. The plate can conveniently be held in place by two strong coil springs which are left permanently in place. This procedure is also useful where units of machinery have to be lifted out frequently for service.
- 3.6.** When rechocking a small or medium speed engine or gear box replace all metal chocks with resin chocks. Do not mix metal and resin chocks. Partial rechocking of large bore slow speed engines is acceptable for a minimum of 1.5 cylinders in one group. To mix iron and resin chocks in an alternating pattern is not acceptable.



Large slow speed diesel only
Nur große langsam laufende Diesel

- 3.7. Small chocks with maximum dimension 300 mm such as found under high speed engines or on deck machinery can have the overpour on all sides if required, when self adhesives foam rubber strips guarantees expansion of the machinery. Larger chocks should limit the overpour to one side of a chock only, and not return round a corner as this can cause the overpour to crack off. This is not important but the owner may become unnecessarily concerned.
- 3.8. Chock length should be short, not exceeding 750 mm if possible and ideally containing only two bolts in a row or four in a rectangle. Short chocks can be achieved by inserting foam dividers into larger chocks. (An exception is continuous grout for flange seals, large roller bearing installations and circular crane rails on deck).
- 3.9. For alignment, note that no allowance is necessary for shrinkage, but an allowance of 0.001 times chock thickness is advisable to compensate for compression upon tightening the holding down bolts, e.g. 40 mm chock thickness may compress 0.04 mm.
- 3.10. **CRITICAL ALIGNMENT APPLICATIONS should be controlled as follows:**
- a. Maximum deadweight loading on EPOCAST 0,7 N/mm².
 - b. Maximum total loading, deadweight plus holding down bolt tension 5,0 N/mm².
 - c. Holding down bolt tension must also meet Classification Society requirements for minimum stress or minimum stretch. Recommended minimum holding down bolt yield stress 600 N/mm².
 - d. For thrust bearings or reduction gears taking thrust collision chocks should be fitted in front and aft end and additionally reamer bolts on each corner should be fitted.
 - e. Continuous chock temperature must not exceed the Classification Society's rule, usually 80°C.

3.11. Plans of main machinery when submitted for approval to the Classification Society should follow the above instructions and include the following information:-

- a. Machinery type and deadweight.
- b. Number and diameter of holding down bolts, diameter of screwed thread. (G.L. require a drawing of the holding down bolts and calculations proving a minimum stretch of 0.172 mm for 5,0 N/mm² total load).
- c. Effective area of chocks.
- d. Bolt tension, bolt torque or hydraulic tensioning pressure, tensioner piston area, and bolt relaxation factor.
- e. Power or propeller thrust (for units taking thrust).
- f. Epoxy resin chock material to be **EPOCAST 36®**.

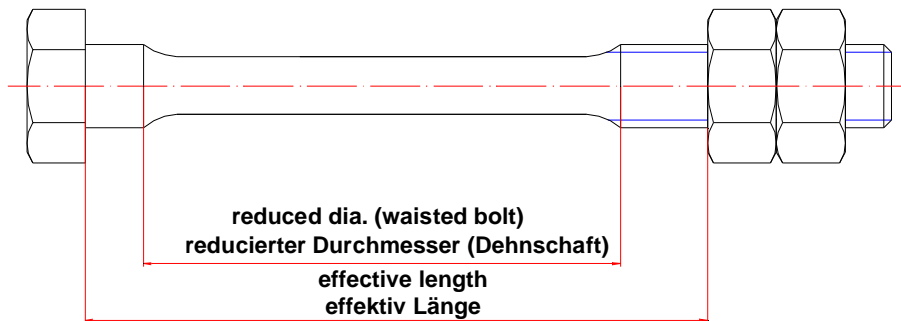
3.12. G.L. has a requirement for minimum bolt stretch 0.172 mm. A basic formula to calculate bolt stretch is:

$$S = \frac{4 \times F_v \times L_k}{\pi \times E \times D^2}$$

Where S = Stretch in millimeters, mm
F_v = Bolt tension in Newton, N
L_k = Effective bolt length in mm
E = Modulus of elasticity of bolt material,
(modulus for steel is 2.07 x 10⁵ N/mm²)
D = Bolt diameter in mm

The bolt diameter may be reduced in the shank. Calculate the stretch separately for each length with each corresponding diameter.

The diameter cannot be reduced to less than 80% of the Minor thread diameter.



3.13. To find the bolt torque from a given tension:-

$$T_p = \frac{F_v \times D}{5000}$$

Where T_p = Torque in Nm
 F_v = Tension per bolt in N

3.14. In the case where bolts are tensioned by hydraulic bolt stretcher, the engine maker will supply the stretcher, stating the effective piston face area to enable the required hydraulic pressure to be calculated. It has been found there is a loss of tension in the bolt when the stretcher is released and this factor is a constant between 0.75 and 0.90 dependent on the bolt length. This is advised by the engine maker. The formula to find the hydraulic tensioning pressure is:-

$$P_h = \frac{F_v}{A_h \times K}$$

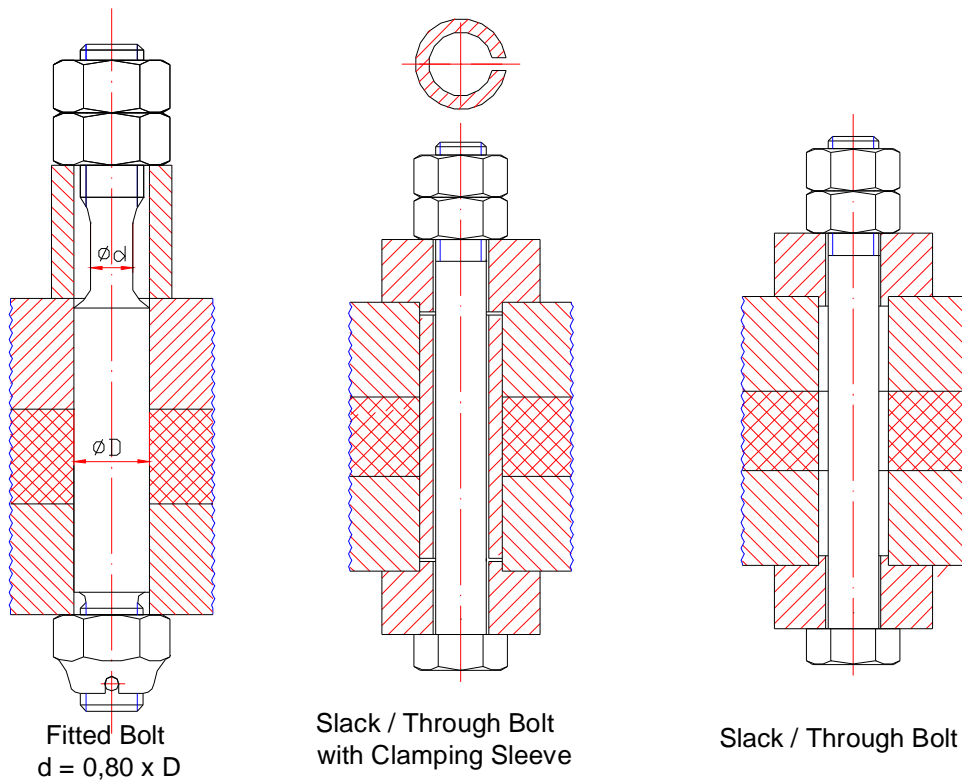
(Multiply N/mm² x 10 to get bar)

Where P_h = Pressure in N/mm² or MPa
 A_h = Area of piston face in mm²
 F_v = Tension per bolt in N
 K = Tension relaxation constant

3.15.

We cannot reduce the diameter of fitted bolts, and the usual procedure in this case is to make a long fitted bolt with a reduced shank above the foundation plate, fitted with an extension sleeve.

If a simple small diameter bolt without extension sleeves can be used for the slack / through bolts, then an elegant solution to the reamer bolt problem is to use a hollow dowel in the reamed hole and to put the simple bolt through it. This has the advantage of keeping one torque, one tension and one stress on all the bolts, and uniform loading on the chocks.



3.16.

The basic calculations are quite simple. The complications arise from considerations of bolt tension, reduced loadings, different lengths of bolt and different bolt material or design. Please consult H.A. SPRINGER GMBH for working out chock arrangement drawings and Class. approval data.

3.17.

The same high safety margins allow us to assume uniform loading over the chock area. If the steel plate were perfectly rigid, the load would be perfectly uniform. This is why thin bedplates and thin foundation plates can give rise to trouble due to distortion.

- 3.18.** NON-CRITICAL ALIGNMENT INSTALLATIONS. The chocks should be arranged as for metal chocks making the size as large as the available chocking surface permits. Generally 400 mm is the maximum useful distance for any chock to extend from the nearest bolt. Torque down normally without a calibrated torque wrench.

If required by owners or Class. calculate exact loading and torque.

Temporary increases above the total load can be accepted. This applies to towing winches, windlasses, crane rails, single buoy moorings, and similar dynamic applications.

- 3.19.** **EPOCAST 36®** is designed and approved for main propulsion chocking and is therefore also excellent for deck machinery and auxiliaries. Generally use **EPOCAST 36®** for all applications. The load bearing capacity of **EPOCAST 36®** and **EPOCAST D** is in proportion to the price (D is 70% of 36), therefore by using less **EPOCAST 36®** you can do the same job as you would have done with **EPOCAST D**. In the case of low chock loading then it is more economical to use **EPOCAST D**.

- 3.20.** Contact H.A. SPRINGER GMBH for additional instructions for any installations. Some examples follow:-

- a. Stern tube and strut bearings.
- b. S.B.M. and large roller bearings.
- c. Crane rails without machining deck.
- d. Z-Drive units, gun mountings, Voith Schneider Propellers.
- e. Mounting large hinges, load bearing blocks.
- f. Gate valves, water tight panels, bulkhead flanges.
- g. **EPOCAST 36-P**, with paste consistency is available for mounting gas tanks, or fixing dock gate seals, or other cases where equipment is fastened onto vertical or inclined surfaces.
- h. Industrial applications, **EPOCAST G**, grout for bulk pours and concrete repair, and **EPOCAST-PI** for pressure injection, **EPOCAST CR** for crane rail chocking and **EPOCAST S** for socketing of wire ropes.

3.21. STRENGTH OF BOLTS

3.21.1 STRENGTH GRADE DESIGNATION SYSTEM FOR STEEL BOLTS AND SCREWS

This Standard includes a strength grade designation system consisting of two figures. The first figure is one tenth of the minimum tensile strength in kgf/mm², and the second figure is one tenth of the ratio between the minimum yield stress (or stress permanent set limit, R_{0.2}) and the minimum tensile strength, expressed as a percentage. For example with the strength designation grade 8.8, the first figure 8 represents 1/10 the minimum tensile strength of 80 kgf/mm² and the second figure 8 represents 1/10 the ratio

$$\frac{\text{stress at permanent set limit } R_{0.2}\%}{\text{minimum tensile strength}} = \frac{1}{10} \times \frac{64}{80} \times \frac{100}{1} ;$$

the numerical values of stress and strength being obtained from the accompanying table.

STRENGTH GRADE DESIGNATIONS OF STEEL BOLTS AND SCREWS

Strength Grade Designation	4.6	4.8	5.6	5.8	6.6	6.8	8.8	10.9	12.9	14.9
Tensile Strength (R_m), Min.	40	40	50	50	60	60	80	100	120	140
Yield Stress (R_e), Min.	24	32	30	40	36	48	...	...	...	...
Stress at Permanent Set Limit (R_{0.2})Min.	...	...	...	...	...	...	64	90	108	126

All stress and strength values are in kgf/mm² units

3.21.2. Strength Grade Designation System for Steel Nuts

The strength grade designation system for steel nuts in a number which is one-tenth of the specified proof load stress in kgf/mm². The proof load stress corresponds to the minimum tensile strength of the highest grade of bolt or screw with which the nut can be used.

STRENGTH GRADE DESIGNATIONS OF STEEL NUTS

Strength Grade Designation	4	5	6	8	12	14
Proof Load Stress (kgf/mm²)	40	50	60	80	120	140

RECOMMENDED BOLT AND NUT COMBINATIONS

Grade of Bolt	4.6	4.8	5.6	5.8	6.6	6.8	8.8	10.9	12.9	14.9
Recommended Grade of Nut	4	4	5	5	6	6	8	10	12	14
Note : Nuts of a higher strength grade may be substituted for nuts of a lower strength grade										

4.0 . MATERIALS, TOOLS AND TEST EQUIPMENT

MATERIALS

1. **EPOCAST 36®** 2000 cc incl. Hardener
2. **EPOCAST 36®** 4000 cc incl. Hardener
3. **EPOCAST 36®** 8000 cc incl. Hardener
4. Mastic
5. Grease
6. Release agent
7. Foam plug for bolt holes
8. Foam damming



TOOLS

1. Mixing blade
2. Electronic heater 2 KW 220 V
3. Electronic mixing drill
4. Scissors

TEST EQUIPMENT

1. Temperature readout and recorder (Thermocouple)
2. Barcol Hardness Tester