Introduction

Although various aspects of the permanent mould casting process have been studied and developed, such as alloy selection, machine automation, etc., little attention has been given to the products and methods for preparing the surfaces of the die.

It is often the operator that selects and prepares the coating material, and the final choice is based almost exclusively on practical experience rather than technical and theoretical considerations. This manual aims to provide foundry engineers and operators involved in die preparation with the information required for the correct use of coating materials, in order to optimise efficiency and so improve foundry production.

This latest revised and illustrated edition of the Foseco **DYCOTE** Manual comprises: An analysis of the functions of coating materials, preparation and application methods, and examples of die preparation for the most common castings.

The tables with the characteristics of **DYCOTE** coatings have been extended and rationalised and some products not catalogued as **DYCOTE** but which have long been used in diecasting have been added. The manual is completed with appendices on cryogenic sandblasting, coating application defects and defects in die-cast parts.

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Diecasting and the Role of Coatings

Diecasting is a process that uses permanent moulds made of metal (dies) enabling large batches of identical castings to be produced. Contrary to sand moulds, in which the permeability of the compacted sand allows the air to escape freely during casting, metal moulds are impermeable and therefore must be designed with suitable air vents. The advantages of the die process over sand are:

- better structural characteristics
- better appearance of the casting
- greater dimensional accuracy
- reduced feed demand
- higher production rates
- reduced cost (for larger batches)

Compared to sand moulds, the use of a permanent metal mould requires completely different conditions for filling the metal alloy and for its solidification; the function of the die coating – a semi-permanent layer deposited on the walls – is to control these processes and to facilitate release of the casting, prolong die life, etc. In diecasting, coating selection and its method of application are at least as important as other factors, such as the design of the die, type of alloy, temperature of the metal and so on. Foseco produces a vast range of die coating products under its **DYCOTE** brand as well as other products and systems which have long been used in all areas of the modern metal foundry. In addition, Foseco is constantly seeking new products and systems to make casting production safer, more environmentally friendly and more economic.

Function of DYCOTE

The principal functions required of a coating for diecasting are:

- Control of the metal flow to ensure that it reaches all parts of the die at a sufficient temperature to prevent the formation of seams, cold laps, etc.
- Control of heat transfer to obtain better solidification and ensure that the castings are properly fed.
- Easy release: since castings are extracted at just below the solidification temperature, easy release ensures that castings do not come out deformed.
- Good surfaces, and therefore a reduction in finishing costs.
- Longer die life, therefore increased productivity and reduced maintenance and cost.

These results are directly in line with the characteristics of DYCOTE.

Heat transfer control

The control of heat dispersal through the various sections of the die is undoubtedly the most important characteristic of DYCOTE, because it permits control of both directional solidification and die filling (which will be discussed in the section "Metal flow control")

The degree of insulation depends on:

- the properties of the raw material used
- the method used to apply DYCOTE to the surface of the die
- the thickness of the layer.

The basic ingredients of DYCOTE are:

• **Fillers:** composed generally of refractory powders such as TiO_2, talc, mica, silica flour, iron oxide, Al_2O_3, etc. At the normal casting temperature of aluminium alloys in the die-casting process (650-800°C), the refractoriness of the fillers is such as to ensure that no chemical reaction takes place. Their function therefore remains exclusively physical, i.e. only thermal conductivity and particle form and dimensions are involved (the importance of the latter factors will be discussed when dealing with metal flow control).

• **Bonding agents:** in the majority of cases sodium silicate with an appropriate SiO_2/Na_20 ratio, although sometimes other materials are used, such as certain types of clays, starch, etc.

• **Water:** with controlled hardness.

The compactness of the layer, which depends on the application method, affects the property of thermal insulation: if the layer is not very compact, contact between particles is slight, and therefore the permeability and insulation properties are greater.
DYCOTE coatings are usually supplied in the form of a paste for dilution with water depending on the type of application (and therefore the degree of insulation) desired, i.e. with brush or spray application; the dilution ratio is relatively unimportant from this point of view, since excess water is removed by heat from the warm die surface, (120-140°C with brush application and around 180-250°C for spray application).
Brush application leaves the die with a very rough surface full of air pockets and this gives it a high degree of insulation, ideal for the surfaces, for example, of runners and risers, not requiring special finishes.
In spray application, DYCOTE coatings are applied in several thin layers until the desired thickness is obtained. In this case the layer also comprises air pockets but they are smaller than in the previous case, and are due to the accumulation of particles rather than the formation of bubbles in the bonding agent.
Air pressure and distance of the pistol from the surface of the die must be sufficient to overcome the phenomenon of evaporation and permit the DYCOTE to adhere completely to the die surface. Air pressure of 2-5 bar and a distance of 25-30 cm from the die is recommended.
Good quality castings with no, or at least only a controlled level of, solidification shrinkage are obtained if the concept of directional solidification is observed, i.e. if solidification proceeds steadily towards the risers from the parts of the casting farthest from them.

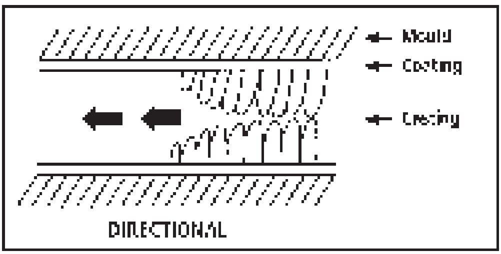

Figure 1 - Directional Solidification

An appropriate coating, with the thickness varying with those of the casting if necessary, allows the control of heat transfer, favouring directional solidification.

For example, by applying opposite a thin section of the casting a thicker layer of a coarse DYCOTE, thereby slowing down solidification, and opposite a thick section a thinner layer of a fine DYCOTE, thereby accelerating solidification, the cooling characteristics of the metal can be rendered sufficiently uniform to give a sound casting. The larger the difference between the sections of a casting, the greater should be the insulating properties of the DYCOTE applied. In extreme cases, for example, the desired effect can be obtained by removing or rubbing down the lining on thick sections and applying a thick coarse layer to thin sections. Runners and risers, where metal has to remain molten for a certain time to feed the casting during solidification, normally require a thick layer of an insulating DYCOTE.

Controlling metal flow

Since the coating is thin (50-200 microns) and the temperature differential between the molten alloy and the die varies between 400 and 500°C, the thermal conductivity stays relatively high and the transmission of heat from the metal to the die is instantaneous and intense. The physical characteristics of DYCOTE (coarseness, filler size), have a marked effect not only on the surface quality of the casting, but also on the flow of metal and degree of insulation. For example, a thin layer with ample contact with the metal increases the transmission of heat and rapidly reduces fluidity; this can result in incomplete filling, cold laps, etc., especially when the metallostatic pressure is low, as for example in the case of castings with thin sections.

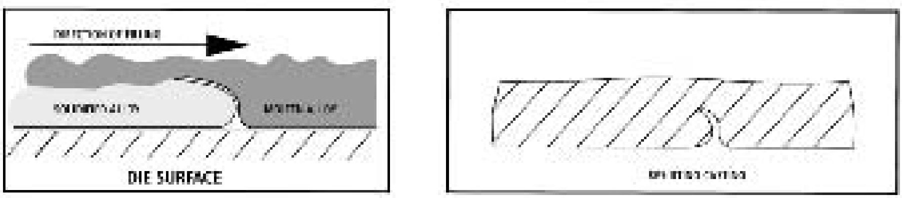

Figure 2 - Model of a cold lap formation

Conversely, with a layer of DYCOTE with a coarse surface, the contact between molten metal and DYCOTE is significantly reduced, because the metal, due to its surface tension, is first in contact with only the “peaks“ of the layer, and only after a time, though this is extremely short, does it penetrate into the "valleys", after which the air escapes through the channels in the permeable coating. The result of this phenomenon is to reduce heat loss to a minimum in the molten metal, which thus maintains its fluidity at the critical moment to fill the die completely.

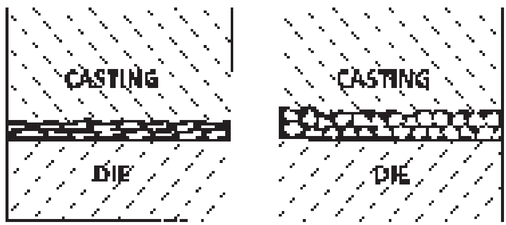

Figure 3 -Effect of the coarseness of coating

The roughness of the refractory particles also influences the flow of metal. Given that the surface tension of aluminium is high, its flow characteristics and wettability are low; as a consequence of this, if a refractory filler with sharp edges is used, the aluminium oxide skin will be continuously broken down during pouring, and the metal will run much more easily over the surfaces. Unfortunately coarse linings with sharp-edged particles tend to become smoother with each casting.

Indeed, the sharp projections of the layer bind to the surface of the casting during solidification and break off during extraction: it may therefore be necessary to touch up regularly to obtain better results consistently.

Easy release

Regardless of the design of the die, release can be made easier by using graphite in a colloidal and semi-colloidal form. Graphite can be used as a component of the refractory base of the DYCOTE in the coating, or applied separately on top of it. When graphite is used in the composition of refractory DYCOTE, care must be taken to avoid weakening the lining due to the thin layers of graphite flaking off, and the undesirable rise in its thermal conductivity. Graphite for application over a layer of DYCOTE base is often used on areas of a die where release is difficult, or on its moving parts. The composition of the DYCOTE must be accurately controlled since, if the bonding agent forms a hard "shell" around each graphite particle, its lubricating properties will be reduced or even completely destroyed. When a graphite-based DYCOTE is applied the lamellae are spread in a disorderly manner, and therefore numerous tiny blisters form in the lining, with the effect of reducing the thermal conductivity of the layer. After a few castings, however, there is a tendency for the graphite film to become flat and impermeable (this can be seen from the shiny appearance of the film after release) as a result of continual friction against the metal caused by shrinkage during solidification. Therefore the bonding agent must be weak, allowing part of the overlaid film to break off, exposing the underlying layer over which the application of graphite is repeated. The drawback here, which arises from having to apply a second coating, is that this tends to cancel out the advantages of particle size in base coats. What happens is that the graphite tends to collect in the „valleys", so that the layer takes on a smoother appearance, reducing the fluidity of the metal.

Recently insulating coatings have been introduced with a composition that includes Boron Nitride (BN), which has a hexagonal graphite-like structure, reduced wettability to molten aluminium and good refractory properties allowing the casting to be released easily as known from graphite. Also the white colour of the product prevents the casting becoming discoloured as may occur with graphite.

Good surface

As seen from the discussion above, a good surface will be linked to the choice of DYCOTE; for example flat thin surfaces require a coarse angular lining which favours the flow of metal. This is because the metallostatic pressure is low and filling the die is facilitated by the continual breakdown of the aluminium oxide film. The surface of the casting will be relatively rough but sound, while a smooth lining would cause filling to be incomplete. The parts of the mould corresponding to thick sections of the casting can be coated with finer DYCOTE coatings, since the metallostatic pressure in these areas is higher. Also the type of application will affect the final result: brush application produces an uneven surface, while spray application produces a smooth even surface.

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Lifetime

The factors that contribute to the life of a lining are:

- Type of bonding agent
- Application
- Type of refractory

The bonding agent must not only resist high temperatures but also the high temperature changes that cause tensile stresses in the lining. Very often sodium silicate is used with a well determined Na_20/SiO_2 ratio, as it not only resists thermal cracking, but over time becomes more resistant to high temperatures and therefore is long-lasting. As stated initially, the application method is important and the die temperature is the most critical factor. If the temperature is too low and consequently water evaporation is retarded, the coating forms an impermeable film that detaches from the die forming blisters, due to steam forming under the layer. Then the layer can contract and detach when it is completely dry, leaving part of the die exposed. If the temperature is too high and water evaporation too violent, the refractory particles, surrounded by a film of water and sodium silicate, will become separated from each other and also from the surface of the die by tiny explosions which take place when the steam is released into the air. The result is a weak, coarse, powdery lining that peels off easily. Although, as has been said, the ratios of the constituents remain constant despite being diluted with water, the ratio of dilution influences the final appearance of the coating. As a general rule, the lower the dilution the weaker the bonding of the coating to the die, but the layer will be coarser, will have lower thermal conductivity, and therefore will have better insulating power.

Magnesium alloys

DYCOTE also adapts to magnesium alloys if, prior to casting, the procedure for preventing the oxidation of the metal is carried out, saturating the die cavity with $Si0_2$, or applying a mixture of sulphur and boric acid to the surface of the die before each casting.

Copper alloys, 60/40 Brass

The major difficulty encountered when diecasting in these materials is the deposit of zinc oxide on the die surface. If it is not removed, it rapidly forms a thickness that renders the surface of the castings unacceptable. The dies are therefore designed so they can be dismantled and immersed in a bath containing a suspension of a carbonaceous material that inhibits the formation of zinc oxide. The carbonaceous material is deposited on the surface in a porous structure, giving it both insulating and lubricating properties. The inhibitor to a certain extent prevents the formation of zinc oxide on the surface. Another advantage of this process is the high production derived from the simplicity of the immersion application method.

Aluminium bronze

In this case DYCOTE coatings can be used for light alloys, together with a second graphite-based coat to facilitate release. Use can also be made of the immersion method described for brass.

Low pressure casting

In this process the metal is injected into a mould mounted on a sealed furnace. The air or nitrogen pressure applied to the surface of the metal causes it to rise and pass into the mould through a tube. The pressure required to move the metal is slightly higher than the metallostatic pressure. There is no back pressure on the metal while the mould is being filled. Normally the same DYCOTE coatings or special versions of them are used as for gravity casting. Cast iron or steel tubes are sometimes used protected by a refractory layer, which can be a coating material with a high insulating power. The best method for applying it is to immerse the hot tube in a fairly thick mixture, then dry the layer very carefully to prevent it peeling off. More and more ceramic tubes are used in low pressure foundries. Most are made in sialon, aluminium titanate or other high dense materials. These types of tubes does not need any extra coating.

Preparing the Die

Cleaning

A fundamental requirement is cleaning the surface to be coated: no residue of previous coatings must remain and also no oil, grease or soot. Cleaning can be performed with wire brushes or by light sandblasting. Recently, dry ice cleaning systems have been developed that allow sandblasting in situ without having to dismantle the die, with clear advantages from the environmental point of view but with problems getting into deep parts of the die. Also a big problem is the loud noise. (see Appendix 1).

To help operators prepare and coat dies, reference can be made to the tables showing the various coating zones in different colours.

WHITE HATCHED WITH YELLOW	Very thick white insulating coating, of the type for risers, applied by brush.
WHITE	Fine relatively insulating coating. Black arrows indicate that the thickness of the coating must decrease in the direction of the arrow.
BLACK	Zone where heat-conducting coatings must be applied, based on colloidal graphite and therefore black.
BLUE	White coating thicker than the surrounding area, but not as thick as the yellow hatched coatings. Also in this area the thickness should decrease in the direction of any white arrows, which will be pointing from top to bottom.

Table 1 - Conventional colours for identifying coating layers

Die temperature

Dies generally operate at a temperature of around 300°C, but the coating must be put on in a variable range between 180 and 250°C, depending on the type of DYCOTE and the degree of adherence desired. As the application temperature increases, the adherence is reduced. Therefore the temperature of the die should be controlled accurately during application, using a contact thermocouple. The temperature to which the die is heated before coating should preferably be higher (250-300°C), after which it is left to cool, preferably under a cover, to the correct coating temperature: this improves the uniformity of the die temperature and avoids intermediate heating when successive layers must be applied. After the die has been coated and before the first casting is poured, it must be heated to working temperature. To get the best results when retouching the coating, it would be preferable first to bring the die temperature down to the recommended coating temperature.

Coating thickness

The coating thickness must be defined and controlled on the basis of the insulation required. Thicknesses in the order of 50 µm and 150 µm are sufficient to get good insulation and also good lifetime.

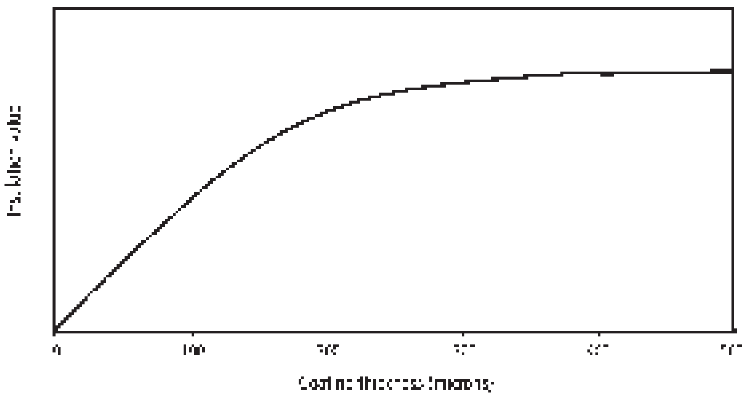

Figure 4 - Typical relationship between coating thickness and insulation

For castings and risers, brush application can achieve a thickness of 4-5 mm. The coating thickness is the principal factor in the heat exchange between casting and die. Coatings applied carelessly over previous coatings result in thick layers with a number of negative consequences, such as alteration of the thickness, poor layer tightness and hot spot defects on the casting. The effect of coating thickness on filling time is illustrated in figure 5; figure 6 shows the effect on solidification time.

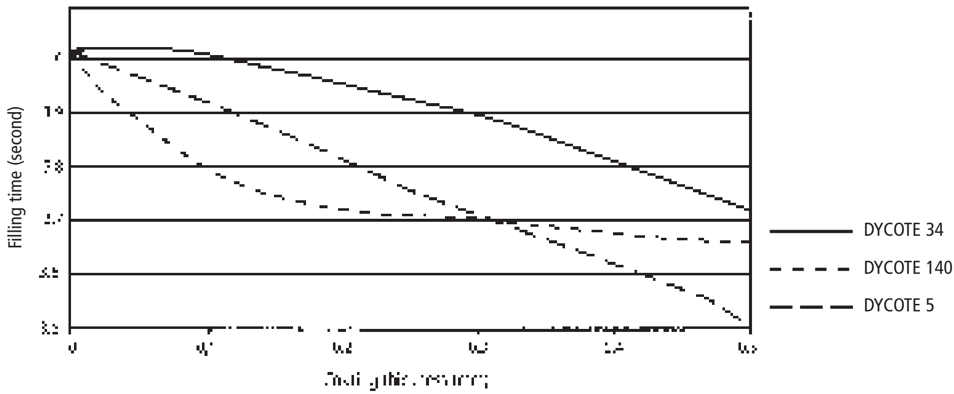

Figure 5 - Relationship between coating thickness and filling time of a test bar (experimental data)

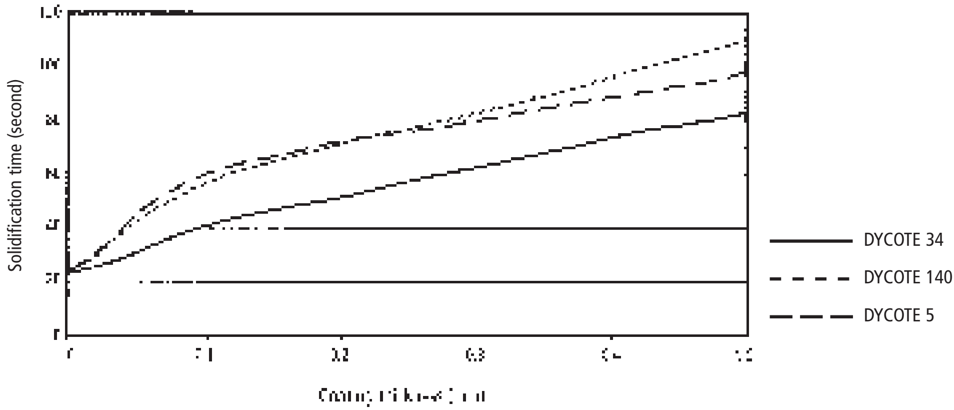

Figure 6 - Relationship between coating thickness and solidification time of a test bar (experimental data)

Coating life

This is certainly the aspect of greatest interest and it is linked to the quality of the DYCOTE and the preparation for the base coat. Thorough cleaning and correct heating are needed to ensure that all types of DYCOTE adhere properly to the die metal. A carefully applied coating should last at least one day, potentially one week. Achieving one day is quite easy, one week needs experience and skill as well as depending upon the casting geometry. Those able to achieve these results will see the benefits especially since the long life of the coating is essential for dies to operate consistently. Recently new compositions of DYCOTE have been formulated, these are called Long Life DYCOTE coatings. A range of fine, medium and coarse Long Life DYCOTE coatings have been developed. Further improvements in coating life can also be achieved by curing Long Life DYCOTE coatings at 400 to 450°C for over one hour immediately after coating.

Preparing the Materials

Adequate storage and appropriate preparation of the coating materials are of vital importance for obtaining optimum performance from the products used. DYCOTE must be stored and applied in an enclosed, cool, dry place not exposed to direct sunlight.

DYCOTE coatings are sensitive to frost.

DYCOTE must be stored at ambient temperature (4-32°C).

Storage at a stable temperature will keep the viscosity and density of the product constant. Too high a temperature leads to changes in viscosity and accelerated biodegradation. Too low a temperature will alter the viscosity and may prevent the use of DYCOTE products which, being generally water-based, will freeze if the temperature falls below 0°C, causing it to lose its gelling property.

Stocks are used on the basis of their “age” (priority is given to materials stored for the longest period), so that the DYCOTE will be as fresh as possible. The quantity of stored product must be such as to enable it to be used before the use-by date on the label. In particular, purchasing the necessary material one month in advance will provide an adequate level of stock.

Preparing the Mixtures

Proper mixing and preparation of DYCOTE is essential for obtaining the correct density, and also for obtaining optimum characteristics of use and reproducibility. Using an appropriate mixer is the best way to prepare DYCOTE. Foseco has developed a system called "DYCOTE Management Station", which in combination with "Carry&Mix" is particularly suited for this. This DYCOTE Management Station is a work shop provided with shelves, sink and automatic water dosing equipment, which allows the operator to mix the DYCOTE with the right amount of water in the Carry&Mix. It is advisable to use the Carry&Mix-version on a trolley with adjustable electric motor, which after preparing the coating can easily be brought to the die preparation area. Carry&Mix is also available in a fixed version without the trolley and with pneumatic motor.

Figure 7

DYCOTE Management Station with shelves, sink and automatic water dosing equipment.

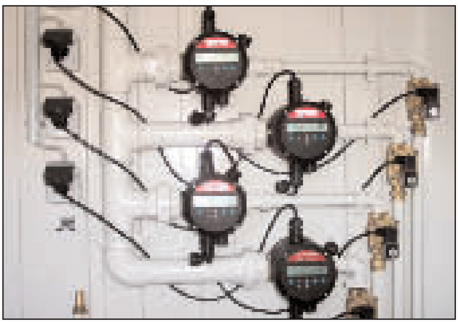

Figure 8 - Carry&Mix

The mixing procedure is as follows:

- Add approximately 1/3 to 1/2 of the total water to the container
- Start the mixer
- Gradually add the correct quantity of paste to form a thick mixture without lumps
- Gradually add water until the mixture is slightly thicker than the density of use
- Once the mixture has a uniform appearance, increase the quantity of water to the required density for the application.

The mixed product must be kept covered. Covering it reduces water evaporation and reduces the risk of contaminants entering the container. The container must be cleaned regularly at least once a month. This is required with water-based products to prevent the formation of biological encrustation.

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Checking and Control

DYCOTE products are subjected to strict quality controls to ensure that they reach the customer in optimum condition, however further controls are required when the product is used. Many of these controls slot easily into the control programmes of the foundry.

Test	Methode	Note
Density	Baumé	Density measurement using a gauge rod with a bulb of calibrated weight at one end, which is inserted into the mixture; the denser the mixture, the less the rod sinks.
	Weight/ Volume	Measurement of the weight of a known volume of material.
Solid content	Dry residue	A weighed quantity of the mixture is dried in an oven and weighed again. The dry residue is the % ratio between the final weight and initial weight.
Viscosity	Ford cup	Viscosity is defined as flow resistance. The viscosity measurement is an indication of the property of fluidity and influences the characteristics of suspension. The Ford cup test measures the time taken for a given quantity of a mixture to flow through an opening of predetermined size. The viscosity is influenced by the temperature, therefore samples should always be tested at the same temperature to obtain meaningful results. Ford Cup tests are not suitable for diluted Dycotes; because of the high amount of water the results are very close together and are not practicable.

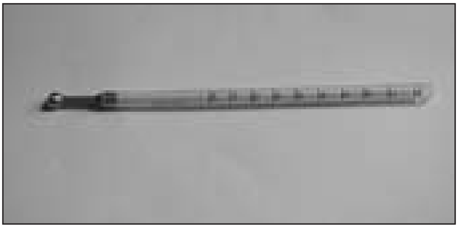

Figure 9 - Baumé densimeter

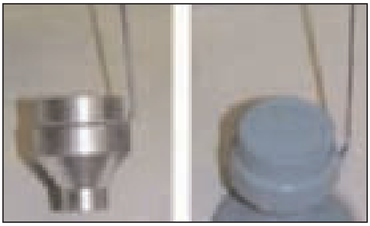

Figure 10 - Ford cup test

Figure 11 - Density measured by weight and volume

Other checks:

- The dilution capacity of DYCOTE should be constant. A given quantity of DYCOTE diluted with a given quantity of water should provide a property of the coating which is constant.
- The appearance of DYCOTE, as is or mixed, should always be the same.
- Signs of lumps or foreign matter can be identified by examining the product.

Application method

The coating can be applied using several methods:

- Brush
- Spray
- Immersion

For dies the quickest and most suitable method is spray application. Brush application is reserved for plain areas (runners and risers) where the lining must be much thicker, or for small details that must be coated in a different way from the rest of the die.

Spray application

Essentially there are two different types of spray devices:

- Siphon pistol (air at high pressure), which uses compressed air to create a partial vacuum that forces the fluid through the pistol, transforming the coating into tiny droplets.
- Air-less systems, pumping the mixture at high pressure into the pistol where it is forced through a narrow portion and then atomised by expansion.

Figure 12 - Krautzberger spraygun

The operations that must be performed to obtain a correct coating are:

- The pistol must be completely clean throughout, particularly the nozzle.
- Fill the tank only with the quantity of mixture necessary. Discard the excess quantity or put it back in the mixer for application.
- Use the product in the pistol without lengthy stops (>10 minutes).
- Set the line pressure to 2-3 bar (depending on the dilution of the mixture). Too much or too little pressure causes the formation of drops instead of a mist.
- Start the coating runs from outside the die and avoid spraying intermittently. Make short passes and keep the pistol moving all the time.
- Maintain a distance of 20-30 cm between pistol and die.

• Work quickly but carefully. Each pass cools the die a little.
• If the distance of application is too close, the coating tends to become thicker, slow to dry and can cause stains on the casting; the layer tends to become too thick.
• If the distance of application is too great, part of the water medium evaporates before contact with the die (dry spray), producing coarse surfaces on the resulting casting and poor coating adhesion.
• It is preferable to apply the coating in several thin layers rather than in one or two thick layers.
• Between one layer and the next, the coating must be allowed to dry.
• The operator should move around the die to coat from several directions and so reach the surfaces to be coated from different angles, thus avoiding the "shadow" effect. This practice also avoids accumulating too much coating material on the operator's side and getting "dry spray" on the opposite side.
• Do not allow the coating to run on the die.
• Always clean the equipment after use.

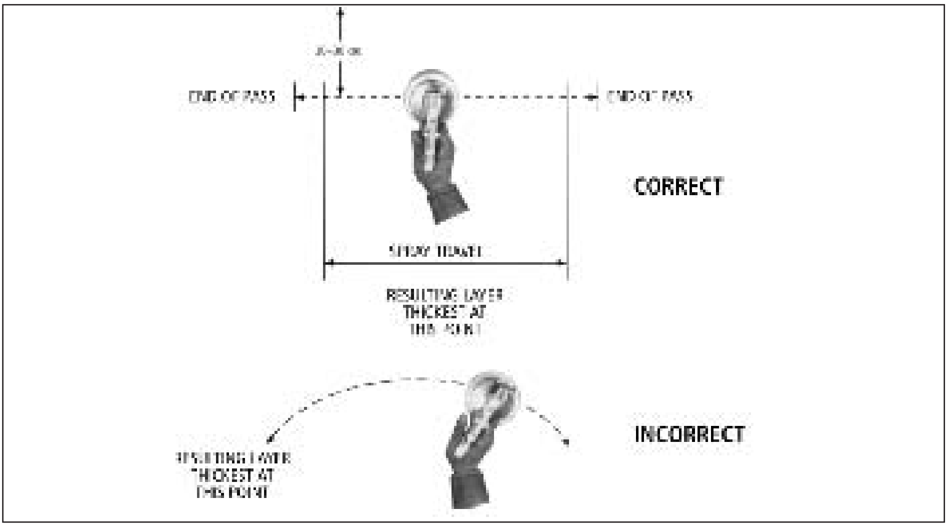

Figure 13 - DYCOTE spray application method - pistol positions

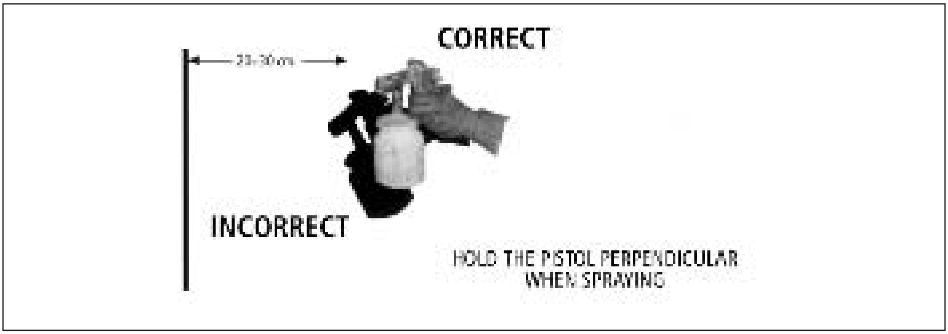

Figure 14

Controlling the Thickness of the Coating

The thickness of the coating is a difficult parameter to control, because of the difficulty of working on very hot surfaces, therefore operators have always been left to work it out from experience, the result being inconsistency from one die to the next and between surfaces of the same die. Thickness gauges are currently available which can be used on hot dies, at all points. This allows the caster to relate the coating thickness to the metallurgical structure of the casting and, by adopting the correct spraying system, to correct the thickness, adapt it to requirements and avoid scrap. Controlling the coating thickness also permits better control of directional solidification, important for ensuring sound castings.

Figure 15

Magnetic system
"Pull off Gauge 157"
Elcometer Instruments
Ltd. Manchester

Figure 16 - Ultrasonic system Sonacoat F

Controlling Die Temperature

Die temperature is a parameter that is generally controlled, even though in some cases experience overrides normal control before application, with the result that sometimes the coating does not bind or last long.

Contact thermocouples and thermometric crayons are now available for controlling die temperature. This enables the caster to apply the various mixtures at the correct temperatures.

Figure 17 - Contact thermocouple

Foseco DYCOTE Coatings

DYCOTE	Grain size Microns	Dilution Vol. water: Vol. coating	Description
DYCOTE 11	10	12:1 to 15:1	Water-based graphite for release of castings from die.
DYCOTE 11 I	10	6:1 to 10:1	Semi-colloidal graphite. For fast cooling and good release.
DYCOTE 14ESS		3:1 to 4:1	Medium insulation with anti-flaking properties. Designed for Low pressure wheel applications.
DYCOTE 140	20 to 40	3:1 to 5:1	Average insulation average surface finish, used for general engineering castings.
DYCOTE 140 CI	20 to 40	1:1 to 4:1	Highly insulating. Mainly used for risers and runner bars.
DYCOTE 140ESS	20 to 40	3:1 to 5:1	Average insulation, average surface finish, used for general engineering castings. Extra binder.
DYCOTE 1450	35	1:1 to 3:1	Long Life DYCOTE with average surface finish, slightly improved life on die. Automotive castings
DYCOTE 2013		1:1 to 3:1	Good insulation. Mainly to protect tools.
DYCOTE 2030	35	1:1 to 3:1	Very high insulation Long Life DYCOTE with coarse particles. Cylinder heads and blocks
DYCOTE 2040	35	1:1 to 3:1	Insulating Long Life DYCOTE with coarse particles for automotive castings.
DYCOTE 2050	35	1:1 to 3:1	Medium insulation. Long Life DYCOTE for thicker section automotive castings. Better surface finish than 2030 and 2040.
DYCOTE 32ESS	20 to 40		Medium insulating coating containing limestone / iron oxide for alloy wheels.
DYCOTE 34ESS	40 to 60	3:1 to 5:1	Very highly insulatuing coating for thin section castings typically automotive. Textured casting finish.
DYCOTE 36		3:1 to 5:1	Coating with insulating and lubricating fillers for dies with low draft angles, ie difficult to extract casting.
DYCOTE 36C	35	3:1 to 5:1	Medium insulation and good release. Also for copper alloys.

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DYCOTE	Grain size Microns	Dilution Vol. water: Vol. coating	Description
DYCOTE 36C	35	3:1 to 5:1	Medium insulation and good release. Also for copper alloys.
DYCOTE 370			Improved insulation DYCOTE 140 type with similar surface finish.
DYCOTE 38	5 to 20		Water-based graphite for release purposes. Thinner than DYCOTE 11.
DYCOTE 39		3:1 to 5:1	Low insulation, very good surface finish, used on front face of wheels where no machining allowed.
DYCOTE 390		3:1 to 5:1	Customer-developed coating with perlite to increase insulation. Based on Dyc.140.
DYCOTE 3950	35	1:1 to 3:1	Long Life DYCOTE. Good surface finish. Particularly for wheels.
DYCOTE 3975			Long Life DYCOTE . Very smooth coating where release is vital. Contains Boron Nitride.
DYCOTE 40	1		Oil graphite blend for slides and moving parts.
DYCOTE 42			Lubricating / conductive coating with silicate binder.
DYCOTE 6	40 to 60	3:1 to 4:1	High insulation coating for general engineering castings.
DYCOTE 61		12:1	Water-based coating containing inhibitor for yellow metal castings used as barrier and for quenching die.
DYCOTE 70			Customer recipe. DYCOTE 140 with gritty particles as in DYCOTE 34. Automotive castings such as manifolds.
DYCOTE 8	60 to 80	2:1	Textured, highly insulating coating for risers and running system. Can be applied by brush.
DYCOTE 9770			Similar to DYCOTE 140, but with higher insulation.
DYCOTE D 212F			Graphite-based coating for release. Without binder. Competitive version of DYCOTE 11.
DYCOTE D 34	80	3:1 to 5:1	High insulation for cylinder heads.
DYCOTE D 34 ESS	80	3:1 to 5:1	With extra binder.
DYCOTE D 38	1 to 5	10:1	Fully colloidal graphite lubricating coating without binder.
DYCOTE D 39	15	3:1 to 5:1	General use smooth surface, good surface finish. Specially for wheels.
DYCOTE D 39 ESS	15	3:1 to 5:1	Extra binder.
DYCOTE 40506	50	2:1	Coating with modified binder system for an advanced lifetime

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DYCOTE	Grain size Microns	Dilution Vol. water: Vol. coating	Description
DYCOTE D 5		3:1 to 5:1	Insulating DYCOTE with good release properties (automotive parts / braking systems).
DYCOTE D 6 ESS	85	3:1 to 5:1	High insulation for cylinder heads.
DYCOTE D 6 ESSB	85	3:1 to 5:1	Extra binder.
DYCOTE D 7039	78	3:1 to 5:1	Insulating DYCOTE for top core of wheels and ribbed cylinder heads.
DYCOTE D BN120	35	10:1 to 20:1	Smooth surface finish with long life. Contains Boron Nitride. Wheel castings.
DYCOTE D BN7039	78	3 : 1 to 5 : 1	Coarse coating with good surface finish. Contains Boron Nitride.
DYCOTE D R787	10	3:1 to 5:1	Fine surface finish. Specially for application at high temperatures 450 - 500 deg C.
DYCOTE D R87	18	1:1 to 3:1	Base coating, apply at 180 deg C.
DYCOTE E11		10:1 to 2:1	Similar application to DYCOTE 11. Semi-colloidal graphite.
DYCOTE E36			Semi insulating coating, for complex shapes and large surfaces. Similar to 36C.
DYCOTE F140	20 to 40		Highly insulating. Mainly used for risers and runner bars.
DYCOTE F34	40 to 60		General use. Good insulation for thin and large sections.
DYCOTE F36			Medium insulating DYCOTE / good surface finishing and good release for small pins with low draft angles.
DYCOTE F39			Low insulation and flowability. General use, smooth surface,.good surface finish. Specially for wheels.

Other	Description
DYCOTE HARDENER	Dycote Hardener. To add, mix to DYCOTEs to improve adhesion on die.
DYCOTE 7029	High insulating paste for feeder and runner systems. Use with the brush up to 3mm is possible. Application at 110-140°C.
DYCOTE 140/3	Coating for automatic ladles.

All Dycotes are available in different pack sizes.

Selection of DYCOTE coatings

- A number of factors must be taken into consideration when selecting a DYCOTE.
- The section thickness of the casting. One of the main properties of a coating is its ability to aid the filling of the die. When the casting concerned has a thin section then a coarse DYCOTE with high insulation properties should be considered.
- The surface finish requirement of a casting is very important but coatings which give very good surface finish make it more difficult to fill the die because of the smooth surface of the coating and because the insulation is not as good as with a coarser coating. The balance of surface finish and insulation will therefore be a compromise.
- The geometry of casting can also be critical for good feeding. If a casting has certain thick sections then a specific coating may be required to help directional solidification.
- Where a casting has small draft angles, because of design, then a coating with excellent release may be required.
- The casting process may also influence DYCOTE selection as low-pressure castings can be made with coatings which have different characteristics from those used for gravity castings.

Some Causes of Problems Experienced with Permanent Die Coatings

- Flaking Of Coating
- Coating Wears Away Quickly
- Coating Won't Stick To The Die
- Coating Is Too Rough
- Misruns / Cold Shuts

Flaking of coating	Coating wears away quickly	Coating will not adhere to the die	Coating surface is too uneven	Misruns / Cold Shuts
Layer too thick.	Spray distance too great	Coating has been frozen	Coating is under-diluted	Incorrect coating selection
Coating under-diluted	Die too hot	Lack of die surface preparation	Spray distance too short	Insulating coating layer too thin
Lack of surface preparation - poor cleaning	Coating under-diluted	Die temperature too low / high	Plugged or worn spray nozzle	Coating too smooth
Die temperature too low	Coating has been frozen		Low spray pressure	
	Contaminated coating			

Appendix 1 – Die cleaning with CO_2

The technique known as „cryogenic" sandblasting is carried out by projecting pellets of solid carbon dioxide (dry ice) onto the die, instead of the usual sand or metal shot. Use of non-abrasive dry ice removes the coating without causing damage or wear to the die. In fact the action performed is exclusively kinetic and thermal. Carbon dioxide pellets, after striking the surface of the die, sublimate (pass into the vapour state) without producing deposits or wetting the die. The temperature loss of the die is very limited, and it is possible to proceed with another coating in a short time. With this system, which is becoming increasingly popular in foundries, frequent coatings can be applied, increasing the life of the die and avoiding the problems met when using sand or shot.

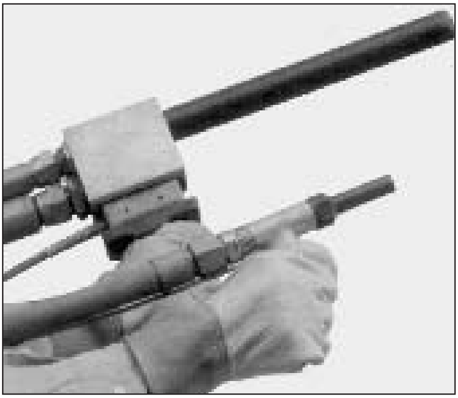


Figure 18 - Sanblasting system

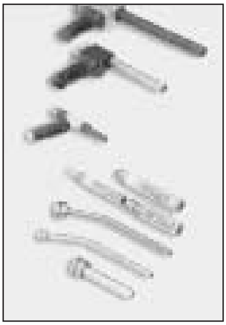
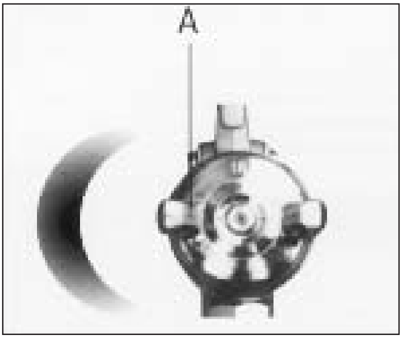


Figure 19 - Parts of the sandblasting system

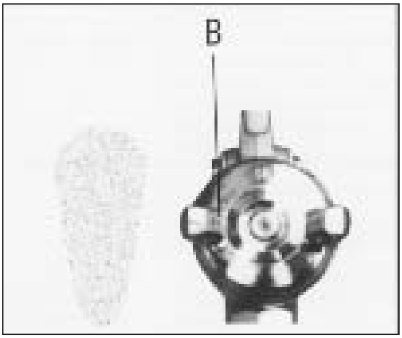
Appendix 2 - Coating Method Defects



Cause
Build-up of coating material restricts air flow in hole "A", with consequent increase of air flow in the hole opposite and direction of spray to the obstructed side.

Remedy
Remove the build-up (with diluents) without using metal instruments that could damage the nozzle.

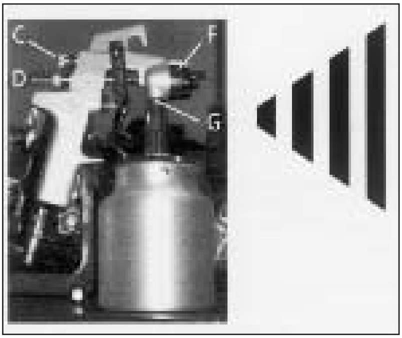
Figure 20



Cause
1) Build-up of coating material around the nozzle on side "B" restricting the flow of atomising air.
2) Air loss, or nozzle tilted or dented, or bent needle.

Remedy
1) Remove the build-up (with diluents) without using metal instruments that could damage the nozzle.
2) Change the nozzle and/or needle.

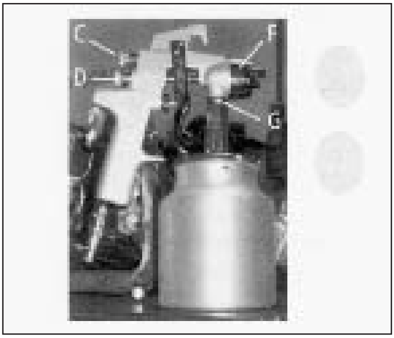
Figure 21



Cause
Air trapped in coating material, due to absence or wear of the seals, defective collar or punctured aspiration pipe.

Remedy
Check all seals for tightness and check all points where air might be sucked into the coating material.

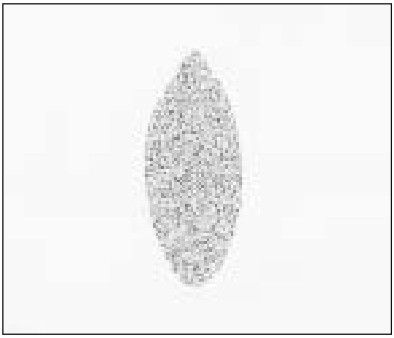
Figure 22



Cause
Spray split in two:
1) Air pressure too high.
2) Coating diffuser aperture too large in relation to the dilution of the coating.
3) Shortage of product in the tank.

Remedy
1) Reduce air pressure.
2) Reduce aperture of diffuser (regulators "C" and "D").

Figure 23



Cause
"Salt and pepper" spray effect caused by insufficient pressure or coating too thick.

Remedy
Increase spray pressure.

Figure 24

Foseco International Limited
PO Box 5516, Tamworth, Staffordshire, England B78 3XQ
Phone: +44 (0)1827 262021, Fax: (0)1827 283725
www.foseco.com
Please contact your local Foseco Company

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