omas Broadbent and Sons Limited
Sugar Division

Information Sheet SI/97/2
(Revision A)

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Inspection of Sugar Centrifuge Baskets

DANGER

IMPORTANT SAFETY INFORMATION

Sugar Centrifuge baskets are highly stressed components. At full speed, the rotational kinetic energy of even a small 1 Tonne capacity basket is equivalent to the kinetic energy of a family car travelling at about 200 mph (300 km/hour). If the basket were to fracture, debris would not be contained within the monitor casing. For this reason, great care is given to the design, selection of materials, manufacture, and testing of baskets.

Baskets should only be used for purposes agreed at the time of sale and notified at such time to Thomas Broadbent and Sons Ltd. Baskets must **NOT** be used with **DIFFERENT MATERIALS** and must **NOT** be run at **HIGHER SPEEDS** without the written approval of Thomas Broadbent and Sons Ltd.

Corrosion and wear in service inevitably reduce the strength of the basket. For safe and reliable operation, baskets **MUST BE INSPECTED EVERY 12 MONTHS** to ensure that this degradation remains within the design limits as defined in this procedure. Any basket failing to meet any one of the acceptance criteria must be removed from service. Repairs must not be attempted without first obtaining the guidance and approval of Thomas Broadbent and Sons Ltd. **IN CASE OF DOUBT REMOVE THE BASKET FROM SERVICE IMMEDIATELY** and contact,

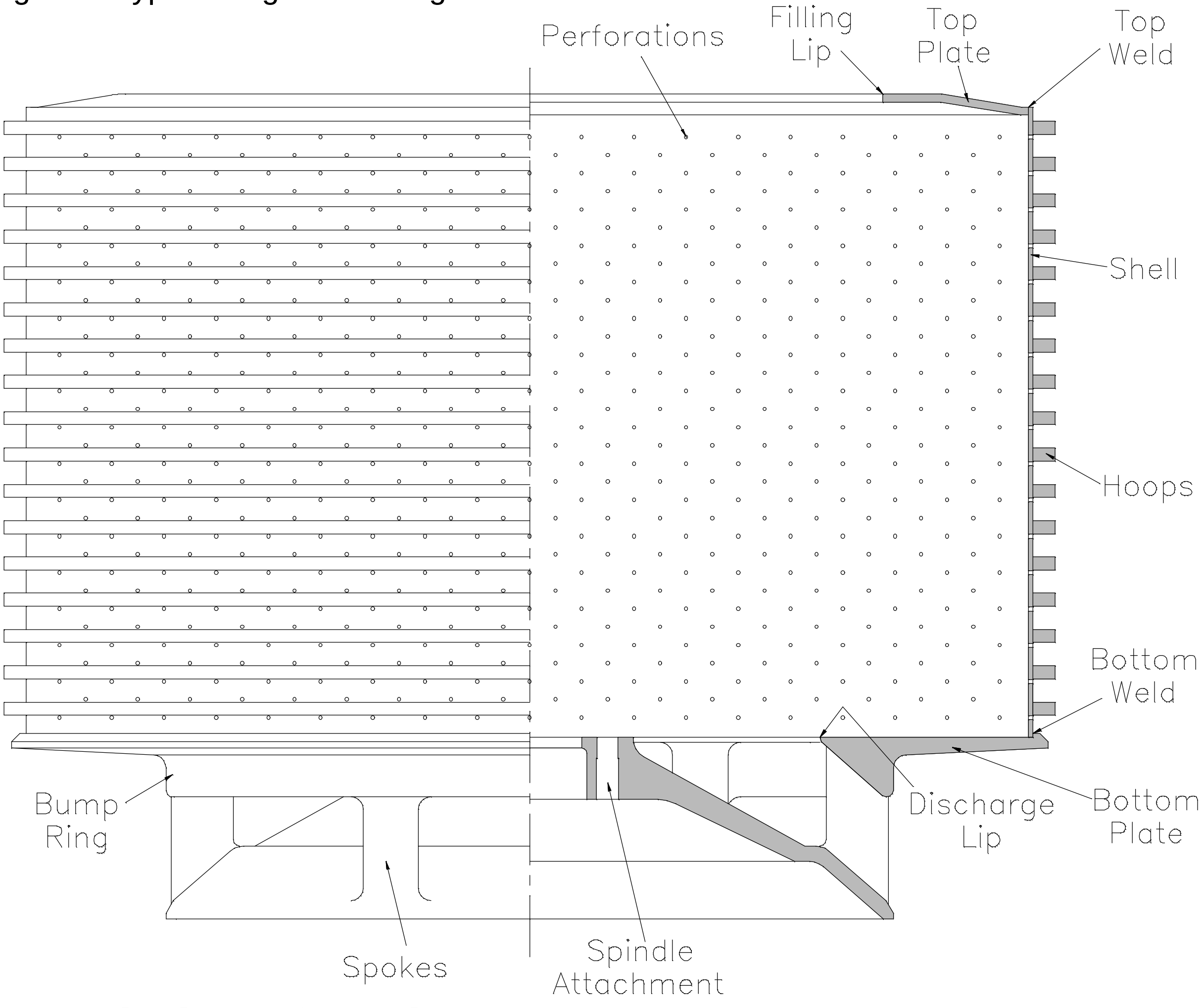
BROADBENT CUSTOMER SERVICES LTD
Huddersfield, HD1 3EA, England
Telephone: 01484 422111 Telex: 51515 TBS G Fax: 01484 516142
Outside Normal Office Hours: Telephone 01484 424660 (Emergencies Only)

FAILURE TO COMPLY WITH THIS PROCEDURE COULD RESULT IN SEVERE OR FATAL INJURIES

General

For safe and reliable operation, baskets must be inspected at intervals not exceeding 12 months of operation. The inspection must be carried out by a responsible person with sufficient practical and theoretical knowledge to understand and apply the procedures detailed below. The inspection procedure involves ***Visual Examination***, ***Crack Detection*** (by Liquid Penetrant or Magnetic Particle Testing as appropriate) and ***Dimensional Checks***. The inspector must examine the basket in ***all*** of the ways stipulated in order to detect faults and weaknesses and assess their importance in relation to safe operation. The results of the examination must be recorded by the inspector and then countersigned and filed by the user. These results should be used for reference at the next inspection when defects noted previously can be located and checked.

Figure 1 Typical Sugar Centrifuge Basket



Description of Basket

Figure 1 shows a typical Broadbent basket. The ***Bottom*** is a casting or fabrication with a central hub for attachment to the spindle, a spoked opening to allow discharge of the sugar, and a flat outer plate. The bottom usually incorporates a Bump Ring which is designed to be the first point of contact between the basket and casing in the event of a large out of balance. The cylindrical ***Shell*** is rolled from plate with a single radiographed seam weld and is perforated to allow escape of the molasses. The ***Top*** is a dished plate whose inside diameter or Lip defines the maximum possible thickness of massecuite cake. Depending on the basket speed and shell materials, the shell may be reinforced by ***Hoops***. These are made from seamless rolled ring forgings in high tensile materials which are shrink fitted onto the shell and retained by small spacers tack welded to the shell.

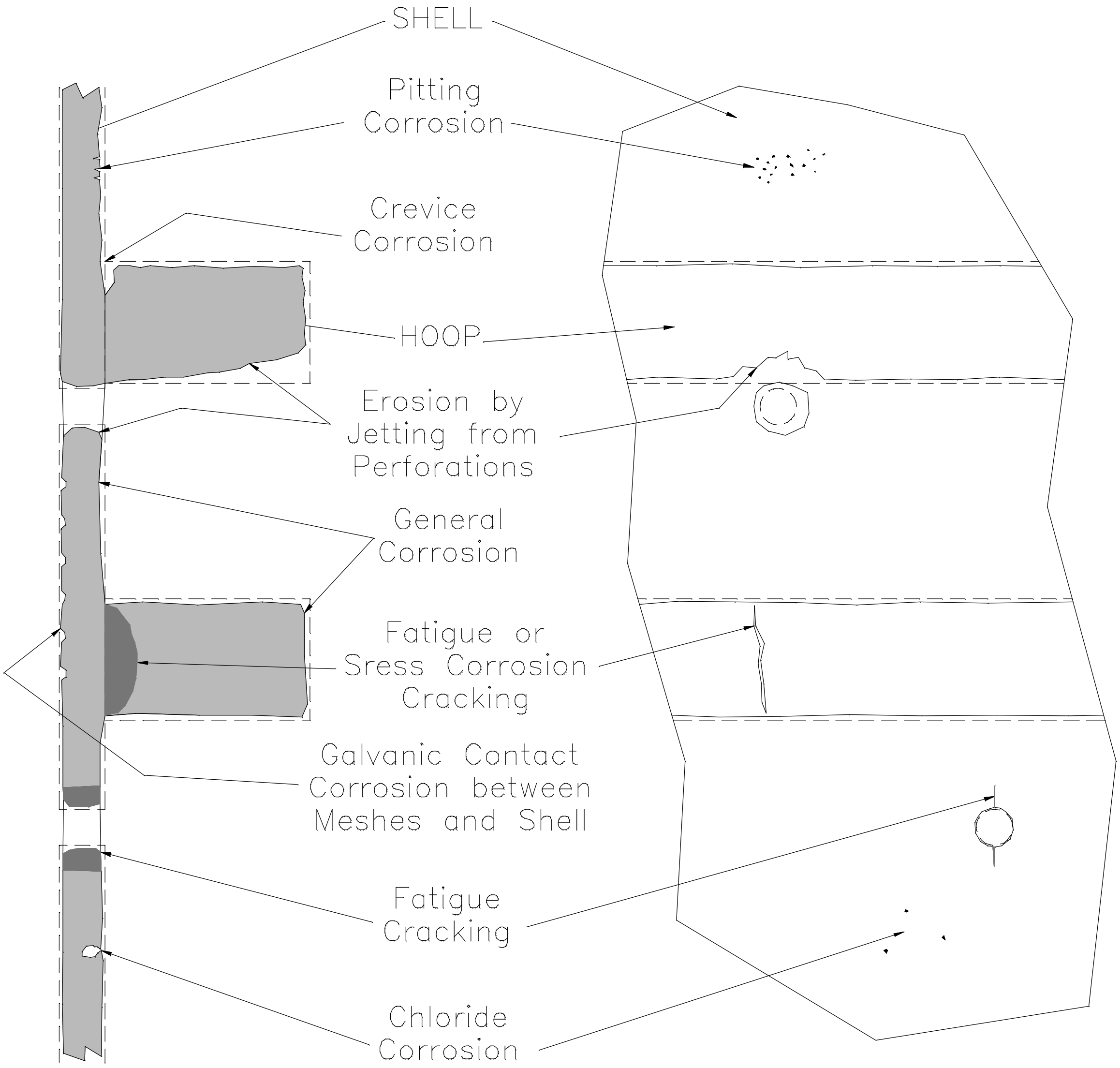
When the basket rotates, centrifugal forces are generated on the product load and also on the basket itself. All these must be carried by circumferential stresses in the shell and the hoops. The basket is designed so that these stresses are within the strength of the materials with allowances for occasional incorrect operation, stress concentration effects, and a degree of thickness reduction due to corrosion. These allowances are taken into account by this inspection procedure and ***once these allowances are used up there is no further margin of safety***. It should also be noted that if the thickness of the shell or hoops is reduced in just one place, the weights and the centrifugal loads will be virtually unchanged but the area carrying these loads is reduced locally and so the stresses are much higher and may exceed the safe limits so,

WARNING: Measuring the weight loss of the whole basket is NOT an acceptable method of assessing the safety of the basket

Types of Defect

To be able to examine the basket competently, it is important to be able to recognize the types of defect which may be present. Illustrations are shown in Figure 2. Examples are given in Figure 3.

Figure 2 Detail of Shell and Hoops illustrating Typical Defects



MECHANICAL DAMAGE

General ***Distortion*** can occur if the basket hits the casing due to a heavy out of balance and may cause the spindle attachment on the basket bottom to twist relative to the bottom plate so that basket runs out of true and the centrifuge vibrates even when empty. In this case, it is usually necessary to replace the basket.

Localized ***Indentation*** of the shell or hoops causing them to be out of round or ***Slippage*** of the hoops on the shell may occur due to accidents in handling. These can affect the strength of the basket and should be referred to Broadbent for advice.

Some degree of ***Scoring*** is to be expected on the bump ring and unless it is very deep this is acceptable. Scoring on the shell or hoops is potentially more serious and should be assessed as surface corrosion.

GENERAL CORROSION AND WEAR

Widespread ***Surface Corrosion*** in the form of ***Rusting*** is to be expected anywhere on carbon steel components. This type of corrosion produces scale which flakes off leaving a rough but not jagged or deeply pitted surface.

Where dissimilar materials touch, electrochemical effects can produce ***Galvanic Corrosion***. For example, stainless steel backing meshes can corrode an impression of themselves into carbon steel shells.

On any materials, the abrasive action of the product moving over surfaces can cause ***Erosion***. Expulsion of molasses through the perforations can wear the shell around the perforations and produce jetting grooves in adjacent hoops. Substantial wear of the basket bottom at the discharge lip is also very common.

The common factor with all these mechanisms is that they progressively reduce the load bearing thickness as time goes on. The effect on mechanical strength of the basket is straightforward to estimate and so the acceptable limits, based on dimensional checks, are well established. In general, the design stresses allow a reduction in load bearing cross sectional area down to a minimum of 80% of the original area. Reductions to between 90% and 80% of the original area are acceptable but must be recorded for checking at the next inspection.

DEEP PITTING CORROSION

In contrast to the general corrosion described above, some materials such as stainless steels are more susceptible to extremely localized ***Pitting*** which is small in extent on the surface but very deep. Some types such as ***Crevice Corrosion*** and ***Chloride Corrosion*** can produce large holes within the body of the material with only a tiny corrosion spot on the surface.

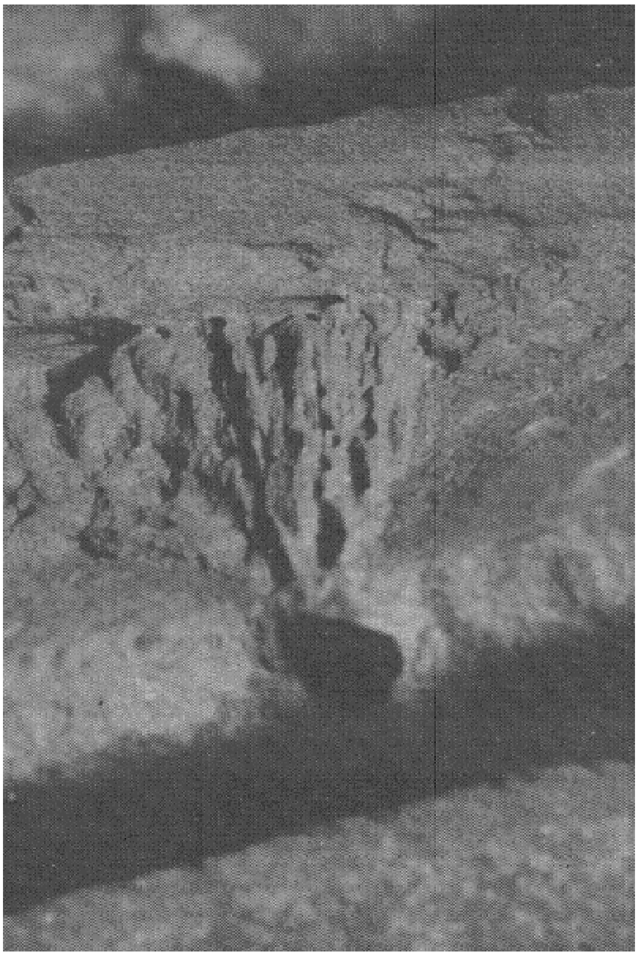
This type of defect is difficult to detect but can have a very serious effect on basket integrity. Ordinary pitting can be an initiation site for fatigue cracks and must be recorded for checking at the next inspection. Baskets showing signs of chloride corrosion must be removed from service immediately.

CRACKS

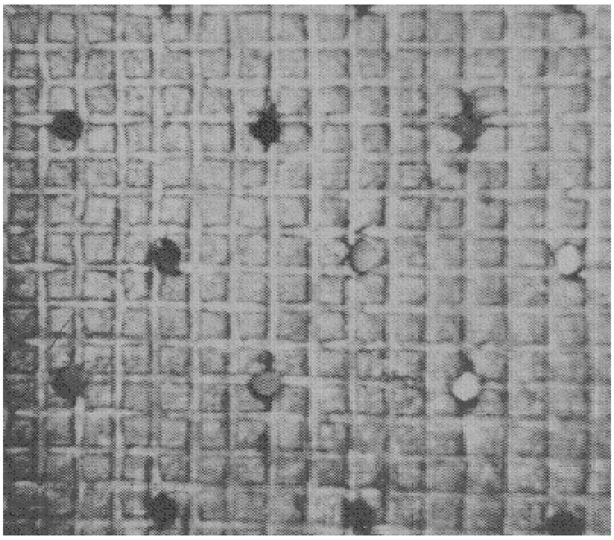
Cracks can be linked with corrosion in the form of ***Stress Corrosion Cracking*** in stainless steels. More often, ***Fatigue Cracking*** is initiated from tiny microscopic defects in the original material or from corrosion pits which then grow as the stresses in the basket increase and decrease with each operating cycle of the centrifuge.

Fatigue cracks are most likely to be perpendicular to the circumferential stresses and in areas of stress concentration such as at perforations or welds. In stainless steel hoops, cracks can propogate from crevice corrosion pitting at the interface with the shell and this is often not visible on the accessible surfaces. By the time cracks are a few millimetres long, most of the fatigue life will have been used up and the component will be in imminent danger of rupturing. Any basket containing cracks must be taken out of service immediately.

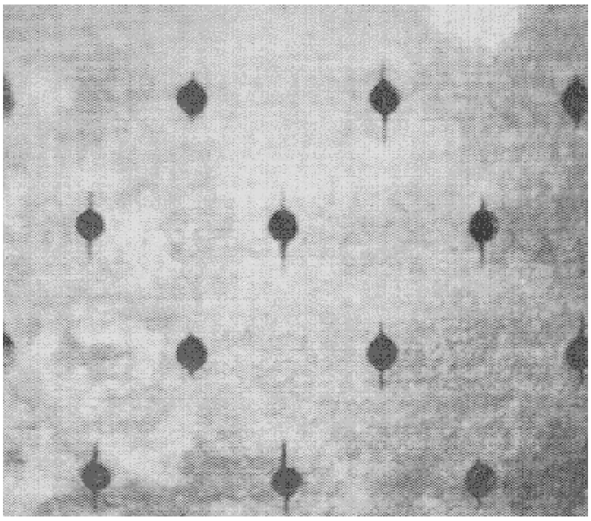
Figure 3 Examples of Serious Defects



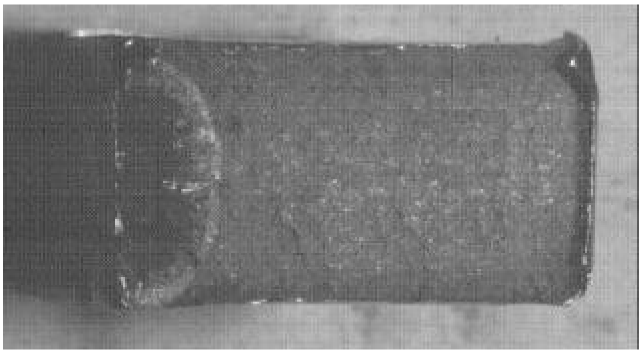
Erosion of Hoops and Shell caused by liquor jetting from Perforations



Galvanic Corrosion on inside of Shell caused by contact with Backing Meshes



Axial Fatigue Cracks in Shell due to stress concentrations atPerforations



Radial Fatigue Cracks in Hoop propogating from crevice corrosion pittting and stress corrosion cracking at face in contact with Shell

In general, ***Carbon Steel*** components are most liable to general wear and corrosion which will be easily apparent but progresses steadily as time goes on so there is unlikely to be any sudden deterioration in basket integrity. In contrast, ***Stainless Steel*** components may superficially appear to be completely unaffected by corrosion even after long periods of time but in fact they are more sensitive to pitting and cracking which are much more difficult to detect but can lead to catastrophic failure. In practice, most basket failures tend to be in stainless steel components.

WARNING: For STAINLESS STEEL components, special care must be given to detailed visual inspection for cracking, pitting and crevice corrosion. It is strongly recommended that stainless steel components are subjected to additional Dye Penetrant and/or Ultrasonic examination

Inspection Techniques

The most appropriate inspection technique depends on the type and material of construction of the component being examined. The following are the most appropriate for centrifuge baskets.

VISUAL EXAMINATION

All components must be thoroughly visually inspected. An overall methodical examination by eye should be followed by detailed examination of suspect areas using a magnifying glass. This is the simplest technique but cannot be relied on to detect cracks and pitting. Visual examination should be regarded as the barest minimum requirement and only for carbon steel components. For stainless steel components, this ***must*** be supplemented by one or more of the following techniques.

MAGNETIC PARTICLE EXAMINATION

In this technique, the component surface is sprayed or painted with a light coloured background covering, an electromagnet is applied to induce magnetic flux parallel to the surface and a suspension of fine dark magnetic particles in a suitable liquid is sprayed or brushed onto the surface. If there are any surface breaking defects, the lines of flux are diverted out of the surface where they attract the magnetic particles giving a clear indication of the defect. This is a well established technique but can only be used to examine magnetic materials and will only detect flaws on the surface.
Magnetic Particle Inspection (MPI) is the recommended technique for examining all carbon steel tops, shells, bottoms and hoops. It is also suitable for martensitic stainless steel hoops but not for duplex or austenitic stainless steels.

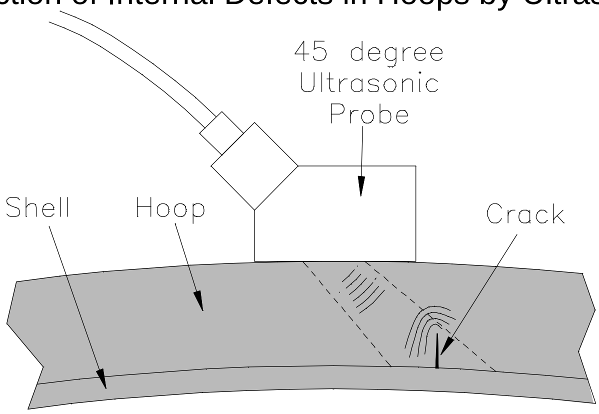
DYE PENETRANT EXAMINATION

In this technique, the component is painted with a brightly coloured, highly penetrating dye. After a pre-determined period, this is wiped off and the surface sprayed with a light coloured, highly absorbent powder developer. The developer draws dye out of any surface breaking defects giving a clear indication. This is a well established technique but it is important that the surfaces are thoroughly cleaned beforehand and can therefore be unreliable on centrifuge baskets due to the difficulty of removing all traces of liquor.
Dye Penetrant Inspection (DPI) is the recommended technique for non-magnetic stainless steel tops, shells, bottoms, and hoops.

ULTRASONIC EXAMINATION

In this technique, a piezoelectric probe applied to the surface of the component radiates pulsed high frequency sound waves into the body of the component. These pulses are reflected back from the back faces of the component but also from any internal defects and are detected by the probe. This is the most practical technique for finding defects which do not appear at the surface but interpretation of the signals is not straightforward and this method should only be used by qualified specialists.
Ultrasonic Testing (UST) is recommended for finding non-surface breaking cracks which can occur in high strength stainless steel hoops (Figure 4) but it can also be used to inspect shells. Since cracks are usually perpendicular to the surface, an angled probe must be used.

Figure 4 Detection of Internal Defects in Hoops by Ultrasonic Technique



The most appropriate non destructive examination techniques for various types of component are given in Figure 5. The alternatives given are technically possible but are generally less reliable for this application. Note that ultrasonic testing is mandatory for all types of stainless steel hoops since this is the only method capable of detecting radial cracking propogating from the contact with the shell as shown in Figure 4.

Figure 5 Recommended Non Destructive Inspection Techniques

	Top, Bottom, Shell		*Hoop*	
	Recommended	Alternatives	Recommended	Alternatives
Carbon Steel	Magnetic Particle	Dye Penetrant Ultrasonic	Magnetic Particle	Ultrasonic Dye Penetrant
Austenitic Stainless Steel	Dye Penetrant	Ultrasonic	Ultrasonic PLUS Dye Penetrant	None
Duplex Stainless Steel	Dye Penetrant	Ultrasonic	Ultrasonic PLUS Dye Penetrant	None
Martensitic Stainless Steel	Dye Penetrant	Magnetic Particle Ultrasonic	Ultrasonic PLUS Dye Penetrant	Ultrasonic PLUS Magnetic Particle

Inspection Procedure

Reference should be made to the information sheet provided with the basket which gives the materials of construction and the original dimensions.

ACCESS

It is essential to have access to all surfaces both inside and outside the basket. The preferred method is to remove the basket from the centrifuge but it is possible to carry out the inspection in situ. All the interior surfaces can be inspected by climbing inside the basket. The outside of the top and top weld can be inspected through the small removable rectangular panel in the monitor casing cover. The outside of the shell, seam weld, bottom weld and hoops can be inspected through the removable panel on the side of the monitor casing. The underside of the bottom and spokes can be inspected from inside the discharge chute. In all cases, the working screens and backing meshes must be removed.

PREPARATION

Remove all loose corrosion scale using a wire brush. Remove stubborn deposits using emery paper. Water wash and then steam clean all surfaces to remove all traces of liquor from crevices. This is essential if liquid penetrant examination is to be carried out.

VISUAL INSPECTION

Methodically examine the surfaces of all components. Check for any signs of mechanical damage such as displaced hoops and bulges or dents in the shell and hoops. Note the areas of worst general corrosion and erosion for carrying out dimensional checks later. Look for signs of pitting and cracking and check any suspect areas with a magnifying glass paying particular attention to the welds, shell perforations and the basket bottom spokes. Assess any findings as detailed in Figure 6.

MAGNETIC PARTICLE, DYE PENETRANT AND ULTRASONIC TESTING

These are strongly recommended as aids to detect pitting and cracking which may easily be missed by just visual inspection. Methodically examine 100% of all surfaces using the recommended non destructive technique as given in Figure 5. In all cases use an accepted procedure (e.g. as used on pressure vessels) to examine all surfaces. Assess any findings as detailed in Figure 6.

Figure 6 Visual, Magnetic Particle and Liquid Penetrant Examination

Observation	*Action*
Hoop slipped on Shell	Submit details to Broadbent for advice
Bulge or Dent in Shell or Hoop	
Scoring	Record and carry out dimensional checks
Wear due to Corrosion or Erosion	
Pitting and Crevice Corrosion	Record
Chloride Corrosion	Remove basket from service immediately
Cracking	

DIMENSIONAL CHECKS

Having noted the areas of worst general wear due to corrosion and/or erosion, check the dimensions in these areas and assess the findings as detailed in Figure 7. For the shell thickness and perforation measurements, it may be worthwhile making some simple gauges.

CHECKS ON SPINDLE ATTACHMENTS

While the basket is removed, both the spindle flange and the fasteners used for attaching the basket to the centrifuge must be carefully inspected. The ***spindle*** is carbon steel and if any signs of cracks are found it must be removed from service immediately. Any corrosion on the attachment face may affect basket concentricity and advice must be sought from Broadbent. The ***fasteners*** may be carbon steel or stainless steel and must be scrapped if any signs of cracking, pitting or thread damage are found. It is strongly recommended that fasteners be replaced every 10 years as a matter of course.

RECORDS

Use copies of the attached form to record the results of the inspection. These records will be found helpful for future inspections.

Figure 7 Dimensional Inspection

Item	*Method*	*Result*	*Action*
Shell	Measure shell thickness using a pin through the perforations	Thickness at any one position less than 80% of original thickness	Remove basket from service immediately
		Thickness at any position between 90% and 80% of original thickness	Record measurements and check at next inspection
	Measure elongation or enlargement of perforation diameter using a plug	Enlargement of any one hole exceeds 120% of original diameter	Remove basket from service immediately
		Enlargement of any holes between 110% and 120% of original diameter	Record measurements and check at next inspection
Hoops	Measure hoop cross sectional area (depth x width) using scale ruler	Cross section at any one position less than 80% of original thickness	Remove basket from service immediately
		Cross section at any position between 90% and 80% of original thickness	Record measurements and check at next inspection
Top	Measure thickness of basket top using long reach calipers	Thickness at any one position less than 80% of original thickness	Remove basket from service immediately
		Thickness at any position between 90% and 80% of original thickness	Record measurements and check at next inspection
Bottom	Measure depth of wear using straight edge across upper and lower faces of bottom plate and spokes	Depth of wear at any one position exceeds 5mm	Remove basket from service immediately
		Depth of wear at any position between 3 mm and 5 mm	Record measurements and check at next inspection

BASKET INSPECTION RECORD

Basket Type	Basket Serial No
Inspected by	Date
Sentence ACCEPT / REJECT	Delete as Appropriate

To specify positions of any defects,
Angles are measured clockwise from serial number engraved on basket top when viewed from above
For Shells, depths are measured down from basket top
For Hoops, numbers are counted down shell from number 1 nearest basket top
For Bottoms, locations are bottom plate upper face, bottom plate lower face, spokes, or attachment hub

TOP					
Material		Original thickness	90% thickness	80% thickness	Thickness of Top
Inspection Method Tick as Appropriate		Visual • Magnetic Particle • Dye Penetrant• Ultrasonic • Dimensional •			
Pitting	Angle				Check at next inspection
	Radius				
Cracks and Chloride Corrosion	Angle				Remove from service
	Radius				
Thickness between 80% and 90% of original	Angle				Check at next inspection
	Radius				
	Thickness				
Thickness less than 80% of original	Angle				Remove from service
	Radius				
	Thickness				

BOTTOM			
Material		Type of Bottom	
Inspection Method Tick as Appropriate		Visual • Magnetic Particle • Dye Penetrant• Ultrasonic • Dimensional •	
Pitting	Angle		Check at next inspection
	Location		
Cracks and Chloride Corrosion	Angle		Remove from service
	Location		
Depth of wear on any surface between 3 mm and 5 mm	Angle		Check at next inspection
	Location		
	Wear		
Depth of wear on any surface exceeds 5 mm	Angle		Remove from service
	Location		
	Wear		

SHELL					
Material		Original thickness	90% thickness	80% thickness	Shell Thickness
		Original diameter	110% diameter	120% diameter	Perforation Diameter
Inspection Method Tick as Appropriate		Visual • Magnetic Particle • Dye Penetrant• Ultrasonic • Dimensional •			
Bulges and Scoring	Angle				Seek advice from Broadbent
	Depth				
Pitting	Angle				Check at next inspection
	Depth				
Cracks and Chloride Corrosion	Angle				Remove from service
	Depth				
Thickness between 80% and 90% of original	Angle				Check at next inspection
	Depth				
	Thickness				
Thickness less than 80% of original	Angle				Remove from service
	Depth				
	Thickness				
Perforation diameter between 110% and 120% of original	Angle				Check at next inspection
	Depth				
	Diameter				
Perforation diameter over 120% of original	Angle				Remove from service
	Depth				
	Diameter				

HOOPS					
Material		Original CS area	90% area	80% area	Depth x Width area of hoop
Inspection Method Tick as Appropriate		Visual • Magnetic Particle • Dye Penetrant• Ultrasonic • Dimensional •			
Pitting	Angle				Check at next inspection
	Radius				
Cracks and Chloride Corrosion	Angle				Remove from service
	Radius				
Cross sectional area between 80% and 90% of original	Angle				Check at next inspection
	Radius				
	Thickness				
Cross sectional area less than 80% of original	Angle				Remove from service
	Radius				
	Thickness				