Thomas Broadbent and Sons Limited
Centrifuge Division

Information Sheet CI/08/1

Inspection of Chemical Centrifuge Baskets

DANGER

IMPORTANT SAFETY INFORMATION

Batch Centrifuge baskets are highly stressed components. At full speed, the stored rotational kinetic energy and strain energy in a basket is very large. If the basket were to fracture, debris would not be contained within the 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,

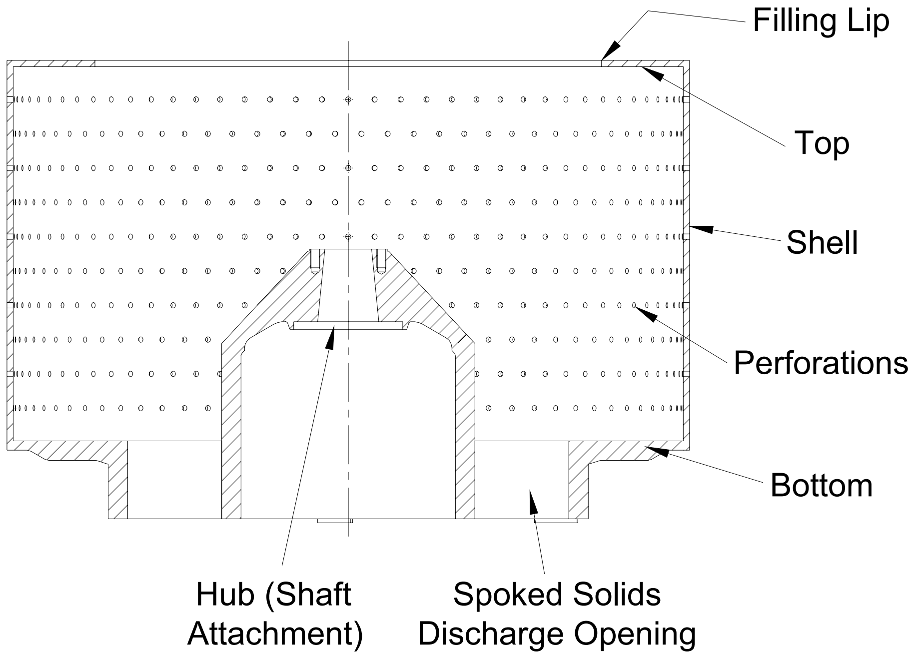
BROADBENT CUSTOMER SERVICES LTD
Huddersfield, HD1 3EA, England
Telephone: 01484 477200 Telex: 51515 TBS G Fax: 01484 516142

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

1 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 Chemical Centrifuge Basket



2 Description of Basket

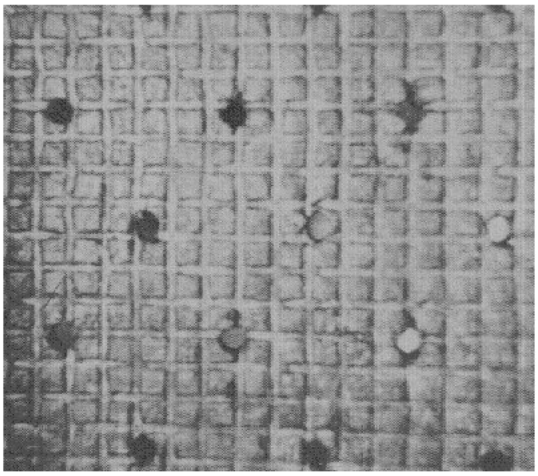
Figure B1 shows a typical Broadbent basket. The ***Bottom*** is a casting or fabrication with a central hub for attachment to the spindle by means of a taper or a bolted flange. It usually has a spoked opening to allow discharge of the solids and a flat outer plate. The cylindrical ***Shell*** is rolled from plate with a single, radiographed seam weld and is perforated to allow escape of the liquid filtrate. The ***Top*** is an annular disc whose inside diameter or Lip defines the maximum possible thickness of slurry cake.

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. 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. A local reduction in thickness produces higher stresses than the same loss in thickness all around the shell. All these factors are taken into account by this inspection procedure and once the specified allowances are used up there is no further margin of safety.

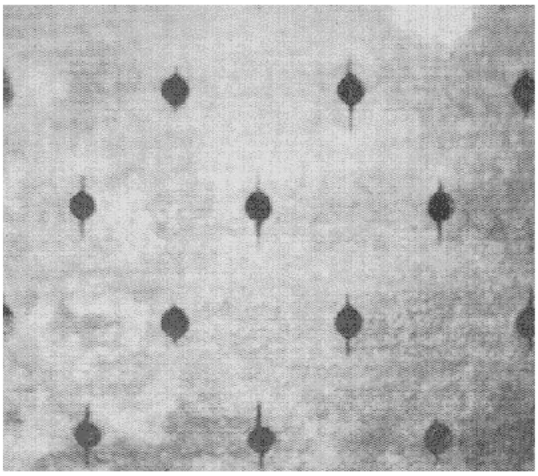
3 Types of Defect

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

Figure 2 Examples of Serious Defects

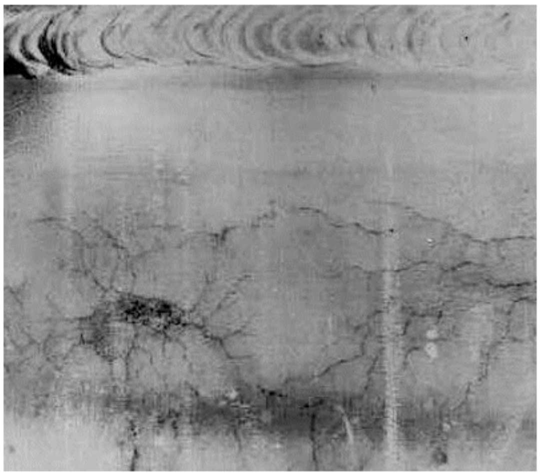


Galvanic corrosion of carbon steel shell by backing mesh



Fatigue cracking at perforations due to mechanical stress cycles

Chloride pitting corrosion of stainless steel cast bottom



Chloride stress corrosion cracking of stainless steel

MECHANICAL DAMAGE

General ***Distortion*** can occur if the basket is subjected to a very heavy imbalance which may cause the shaft attachment hub 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.

Localised ***Indentation*** of the shell causing it to be out of round may occur due to accidents in handling. These can affect the strength of the basket and should be referred to Broadbent for advice. ***Scoring*** on the shell can also be caused during handling and should be assessed in the same way as surface corrosion.

GENERAL CORROSION AND EROSION

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 very aggressive chemicals are being processed, even stainless steels, nickel alloys, titanium etc can be subject to widespread attack reducing the material thickness.

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 the filtrate liquor through the perforations can enlarge the holes and produce jetting grooves in adjacent components. 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 localised ***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 small 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

Mechanical ***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. Cracking can be accelerated by corrosion effects e.g. ***Stress Corrosion Cracking*** in stainless steels.

Fatigue cracks are most likely to be perpendicular to the circumferential stresses and in areas of stress concentration such as at perforations or welds. 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*.

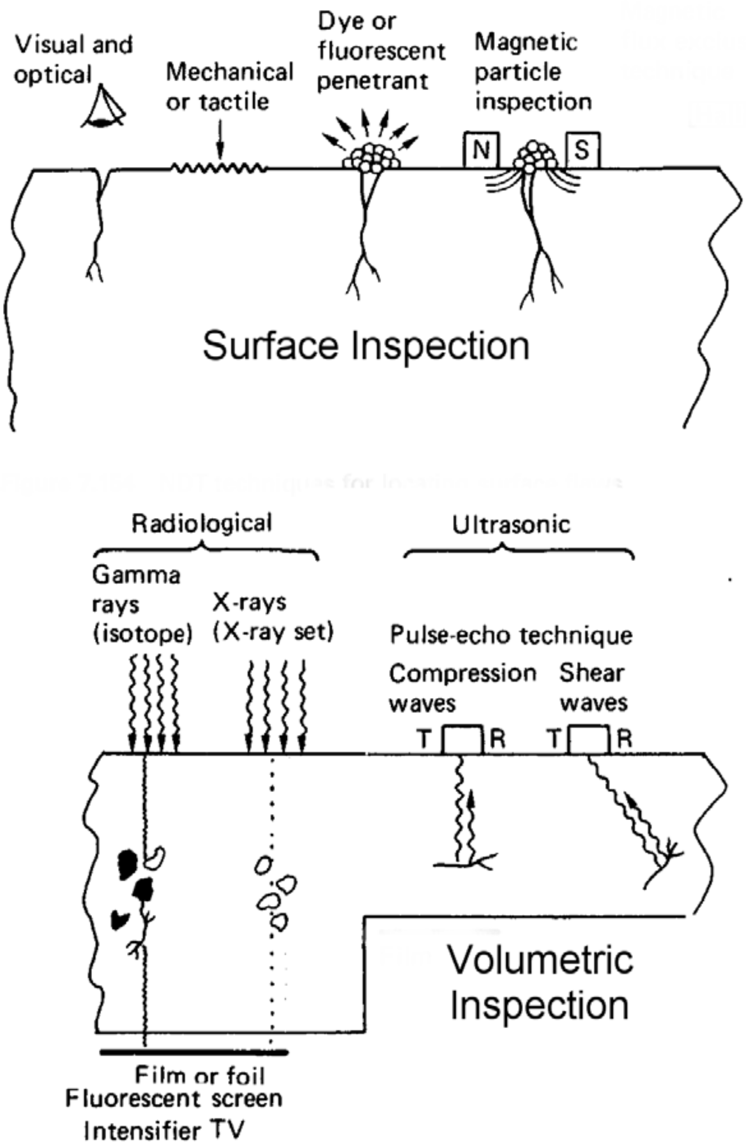
In general, ***Carbon Steel*** components are mainly susceptible to general wear and corrosion which will be easily apparent but progresses steadily as time goes on so there is unlikely to be any sudden deterioration in basket integrity.

In contrast, ***Stainless Steel, Nickel Alloy*** and ***Titanium Alloy*** 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.*

4 Inspection Techniques

The most appropriate inspection technique depends on the material of construction of the component being examined. Figure 3 illustrates the techniques that are the most appropriate for centrifuge baskets,.

Figure 3 Non Destructive Testing Techniques



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, nickel or titanium alloy components, this must be supplemented by other 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. These should be assessed as indicated in Figure 4. This can only be used to examine magnetic materials and will only detect flaws on the surface. Its advantage over liquid penetrant examination is that it is not as dependent on thorough cleaning of the surface.

Magnetic Particle Inspection (MPI) is the recommended technique for examining all carbon steel tops, shells and bottoms but not for stainless steel, nickel or titanium alloy components.

LIQUID OR DYE PENETRANT EXAMINATION

In this technique, the component is painted with a brightly coloured, highly penetrating dye. After a predetermined 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. These should be assessed as indicated in Figure 4. It is vital that the surfaces are thoroughly cleaned beforehand so the method can 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, nickel or titanium alloy tops, shells, bottoms, and hoops.

Figure 4 Acceptance Levels for Dye Penetrant and Magnetic Particle Inspection

Definitions (based on ASME VIII Division 1)
Only indications with any dimension greater than 1.6mm are considered relevant.
A ***Linear Indication*** is one having a length greater than 3 times the width.
A ***Rounded Indication*** is one of circular or elliptical shape with a length less than 3 times the width.

Defect Type	Acceptance Limit
Linear Indications	Not permitted
Rounded Indications	All dimensions of any relevant indication must be less than 5 mm. Four or more relevant indications in a line must be separated by at least 1.6mm edge to edge.

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 a useful 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 of castings can be particularly difficult due to grain effects.

Ultrasonic Testing (UST) is recommended for detailed investigation of defects in any non-cast material. Cracks that most seriously affect integrity are usually those which lie perpendicular to the surface rather than parallel to the surface so a shear wave (angled) probe should be used rather than a compression wave (normal) probe

RADIOGRAPHY

In this technique, a source of high energy ionising radiation (an X ray generating machine or a piece of gamma ray emitting material) is placed on one side of the component wall and a photographic plate or fluorescent screen on the other. Any defects of significant thickness through the wall show up as shadows on the plate or screen. This method works on any material but the component shape or size may prohibit its use. Rigorous safety precautions are necessary to limit exposure of personnel to radiation and so this method can only be applied by specialists.

Radiography is recommended for detailed examination of suspect areas in components of any material. Only cracks that are mainly perpendicular to the through wall direction can be readily detected by radiography but these usually affect integrity far more than cracks parallel to the surface.

The most appropriate non destructive examination techniques for various materials of construction are given in Figure 5. The Primary methods are the basic minimums that should be applied all over. The Secondary methods are those that should be used to investigate in more detail any suspect areas revealed by the Primary examination.

Figure 5 Recommended Non Destructive Inspection Techniques

Material	*Primary Inspection*	*Secondary Inspection*
Carbon Steel	Visual and Magnetic Particle	Radiography or Ultrasonic (not castings)
Stainless Steel	Visual and Dye Penetrant	Radiography or Ultrasonic (not castings)
Nickel Alloy	Visual and Dye Penetrant	Radiography or Ultrasonic (not castings)
Titanium Alloy	Visual and Dye Penetrant	Radiography or Ultrasonic (not castings)

5 Inspection Procedure

Reference should be made to the Technical Data in the Operating Manual 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. In the case of larger centrifuges it may be possible to carry out the inspection in situ by climbing inside the basket, removing inspection panels on the side of the casing, and climbing into the solids 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 particularly important if dye 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 scoring, bulges or dents. 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.

NON DESTRUCTIVE EXAMINATION

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 Primary non destructive technique recommended in Figure 5 and then further investigate any suspect areas using the Secondary non destructive technique recommended in Figure 5. In all cases use an accepted procedure (e.g. as used on pressure vessels) to examine all surfaces. Interpret dye penetrant or magnetic particle indications as detailed in Figure 4. Assess any findings as detailed in Figure 6.

Figure 6 Visual and Non Destructive Examination Evaluation

Observation	*Action*
General Distortion	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 and contact Broadbent
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 SHAFT ATTACHMENT

While the basket is removed, both the shaft flange and the fasteners used for attaching the basket to the centrifuge must be carefully inspected. The ***shaft*** is usually 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 useful for future inspections.

Figure 7 Dimensional Inspection Evaluation

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 to 110% to 120% of original diameter	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

Broadbent Centrifuges	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 Bottoms, locations are bottom plate upper face, bottom plate lower face, spokes, or attachment hub

TOP

Material		Original thickness mm	90% thickness mm	80% thickness mm	
Inspection Method Tick as Appropriate		Visual ☐ Magnetic Particle ☐ Dye Penetrant ☐ Ultrasonic ☐ Radiography ☐			
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 ☐ Radiography ☐	
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 mm	90% thickness mm	80% thickness mm	
	Original diameter mm	110% diam mm	120% diam mm	
Inspection Method Tick as Appropriate	Visual ☐ Magnetic Particle ☐ Dye Penetrant ☐ Ultrasonic ☐ Radiography ☐			

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		