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Transport of Radioactive Material Code of Practice

Guide to Packaging Repair

Produced by the Transport Container Standardisation Committee

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FOREWORD

The Regulations for the Safe Transport of Radioactive Material, Safety Requirements No TS-R-1, 2009 Edition, notes that transport comprises all operations and conditions associated with and involved in the movement of radioactive material; these include aspects of design, manufacture, maintenance and repair of packaging and the preparation, consigning loading, carriage including in-transit storage, unloading and receipt at the final destination [106].

This Guide to Packaging Repair provides guidance on the process to be applied for the repair of packaging to enable them to remain compliant with the requirements for the safe transport of radioactive material. It should be noted that these activities are considered to include the minimum requirements to enable the user to repair packaging in a responsible manner and to operate as an Intelligent Customer.

In particular, this document aims to provide guidance on the activities required to ensure that during service the packaging remains compliant with the design intent.

This document represents good practice and takes the form of recommendations. It should be noted that the word “shall” denotes a requirement; the word “should” denotes a recommendation; and the word “may” denotes permission, neither a requirement nor a recommendation. Imperative statements also denote requirements. To be in compliance with this document, all requirements shall be met but not necessarily all recommendations.

In all cases where a repair is outside the scope of the maintenance instructions it will be necessary to consult the package Design Authority.

CONTENTS

1. INTRODUCTION

This Repair Guide gives guidance and advice on the process of repairing packaging that is used and approved for transporting radioactive material. The guide's target audience is primarily packaging custodians but may also include packaging designers, operators, maintainers and operators of plant who use radioactive material transport packaging, and are involved with turn round inspection.

Because the TCSC documents have a wider readership than the TCSC membership, it has been written to explain to operators and owners of packaging (who may have limited knowledge of the regulations or design and packaging approval processes) how to ensure that a repair is effected without compromising package integrity and ensure that the appropriate approvals are granted. Such owners and operators may not have internal design and repair departments.

The regulatory framework specifically includes repair as part of transport package operations, and consequently should be taken into account when considering any repair. Paragraph 106 of The Regulations for the Safe Transport of Radioactive Material (reference 1) states that “Transport comprises all operations and conditions associated with, and involved in, the movement of radioactive material; these include the design, manufacture, maintenance and repair of packaging.”

Note: Reference 1 The Regulations for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-R-1 2009 Edition is periodically updated and its issue status and content should be checked.

It is therefore important that the organisations and personnel involved in the assessment of any repair, and the repair organisation, are suitably qualified and experienced in the disciplines required. This should include knowledge of the various regulations and standards pertinent to the design, approval and manufacture of packaging used for the transport of radioactive material.

In all cases where a repair is outside the scope of the maintenance instructions it will be necessary to consult the package Design Authority.

Furthermore the organisations would be expected to have management systems in place that are accredited to meet the demands of maintaining quality assurance throughout the repair process.

The examples in this guide cannot be expected to cover every specific situation and it consequently adopts a generic approach for key components of packaging. As far as possible real experience has been brought to bear on the methods described. Each repair will need individual consideration to take account of technical feasibility, economics and maintaining regulatory compliance and design intent.

A list of major standards is included in Appendix I to direct the reader to more specific advice on subjects such as welding, and specialised techniques for testing. This list is not exhaustive but attempts to include those standards that are relevant to repair.

2. SCOPE

This Guide to Packaging Repair provides guidance on the process to be applied for the repair of packaging to enable them to remain compliant with the requirements for the safe transport of radioactive material.

It should be noted that these activities are considered to include the minimum requirements to enable the user to repair packaging in a responsible manner and to operate as an Intelligent Customer.

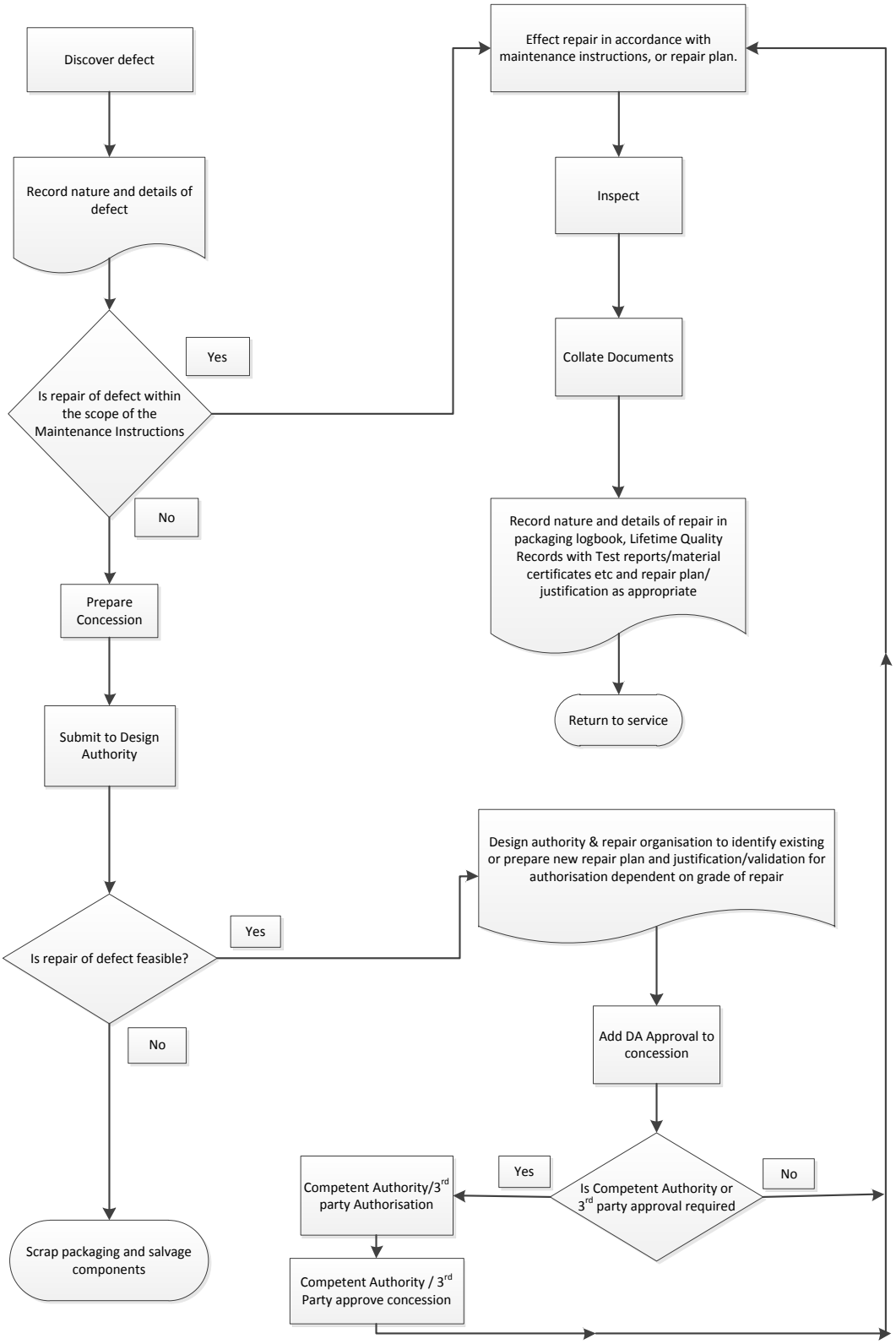
The guide has been written to explain to operators and owners of packaging (who may have limited knowledge of the regulations or design and packaging approval processes) to give guidance on effecting a repair without compromising package integrity and ensure that the appropriate approvals are granted. Such owners and operators may not have internal design and repair departments.

It is intended to integrate the activities and responsibilities of the Design Authority, Competent Authority and the major stakeholders besides the operators and owners.

Furthermore the application of this guide to repairs will assist in ensuring that the design intent and regulatory compliance of any package undergoing repair is maintained.

3. OVERVIEW OF ROUTES FOR SANCTION/APPROVAL/LIAISON WITH DESIGN AUTHORITY

When a defect is discovered the following simple flow chart describes, in overall terms, how the repair process would be applied, and should be followed in conjunction with the notes overleaf.



Notes for flowchart

Discover Defect/Record Nature and details of defect
On the discovery of a defect the details of the defect will be recorded by whatever means is appropriate.

Is repair of defect within the scope of the maintenance instructions?/Effect repair/ record details of repair/return to Service
The maintenance instructions will usually define limited routine repairs and tests required annually (e.g. touch in of paint damage, replacement of worn items, leak tests) and if the work is within the scope of the maintenance instructions then a repair can be effected. The packaging log book or Life-time Quality Records, can then be annotated with the details of the defect and subsequent repair and the packaging returned to service.

Prepare Concession/Bring to Attention of Design Authority
If the defect concerned is not within the scope of the maintenance instructions (eg cracked weld, broken weldment or stripped thread or a simple exchange of a damaged or unserviceable component) then a concession should be raised and the Design Authority consulted. See Appendix III for example concession form.

Is repair of defect feasible?
The decision can then be made whether to repair or scrap. This decision will be made in light of various considerations;

- is it technically feasible to effect a successful repair?
- is it more cost effective to replace the packaging than repair? This will depend on the package type and how it is constructed, as well as the extent of the damage. A 205 litre drum would be scrapped whereas a complex stainless steel containment or fabrication is likely to be repaired. The cost of repair scheme preparation and subsequent approval should also be considered.
- is the failure due to an isolated incident or is it a fundamental design issue? Action may need to be taken to re-brief users/handlers via changes to the operating instructions or the design feature may need to be changed on the whole fleet should it prove to be due to a design defect.
- the age of the packaging and its remaining life
- the availability of build or design records (or a designated design authority)
- feasibility of repair given that the packaging may be contaminated
- availability of spares
- availability of replacement or substitute packaging
- extent of damage/defect

Decision is made that repair is feasible
If a repair scheme does not already exist a repair scheme and plan should be devised by the Design Authority, (with the assistance of the maintainer and/or repair organisation). This will be supported by a justification of the effectiveness of the repair and why the repair does not alter the design intent. Non-destructive testing methods and proof tests may also need to be defined to ensure the original design intent is not compromised.

Add Design Authority approval to the concession
The Design Authority should then formally approve the repair on the concession **before** it is submitted for approval by either third parties or the Competent Authority.

Competent Authority or third party approval required
For packages requiring Competent Authority approval ie Fissile, Type B or C the concession and supporting documents should be sent to the Competent Authority for them to approve the repair and endorse the concession.

The packaging may require a third party approval ie Tank based designs, Freight Containers, or IBC and others reliant on using the alternative requirements for meeting the standards for industrial packages under paragraphs 624 to 628 of reference 1.

For example in the case of repairs to the structure of Freight Containers Approved under the CSC scheme in particular there will be the need to involve Lloyds Register (or another appropriate container approval authority) to assess any repair plan and inspect/witness any repair work and testing

Non-Competent Authority approved designs
The repair scheme shall then be endorsed as acceptable by the appropriate Design Authority.

Effect Repair
Once approvals are obtained the repair can be effected in accordance with the maintenance instructions or repair plan. After inspection of the repair and collation of records the packaging may be returned to service.

4. GRADING AND APPROVAL OF REPAIR

4.1 Introduction

This section considers how repairs should be processed, giving guidance on how a repair may be graded which will determine whether Design Authority or Competent Authority authorisation is required.

Since Quality Assurance relies heavily on learning from experience it is essential that any repair outside of the scope of the Maintenance instructions is referred to the Design Authority for authorisation (and then on to an Approval body or a Competent Authority as advised below). This ensures that the Design Authority is aware of the problems that are occurring in practice and enables them to minimise the chance of re-occurrence (on the Packaging design in question or future designs) by improved design, handling methods, or more detailed operating instructions.

4.2 Non-Competent Authority approved designs

The following gives guidance how and when concessions should be applied for non Competent Authority approved designs.

There are several types of repair;

No concession required

Those that are within the scope of the maintenance instructions and are expected to be routine replacements. This type of repair would generally be simple exchange of wearing (or out of life) components such as seals, fastenings, furniture, filters, markings, cosmetic repair of painted coatings.

Those that are replacement of entire components or sub assemblies that are not expected to be routinely replaced. This is likely to include components such as lids, valves, lifting/tiedown shackles, clamps. Significant repaint beyond cosmetic. This type of repair would usually be by exchange and return the packaging to its original design status/intent.

Concession required

Concessions would be required for;

a) Repairs to components not affecting primary safety (defined as not affecting structural integrity, containment, shielding, or heat transfer) and be beyond a simple exchange of component or repaint that would return to the packaging to its original design intent. This type of repair may involve weld repair (perhaps to a manual lifting point, outer cage, label plate) or thread replacement for a non safety critical fastening.

   It is unlikely that a repair would result in a significant change to the design since any repair would ideally always be to return the package to its original design intent. However, such a repair may also involve a change in design because the event that caused the damage was not foreseen during the design process. Furthermore it may not be possible to effect a repair without changing the design to accommodate that repair. An example of this may be changing the mounting arrangement of protective weather covers or label plates.

b) Repairs that do affect the structural integrity, containment, shielding, or heat transfer of the package.

An example Concession is shown in Appendix II. In reality for major repairs to items affecting primary safety it may be that economic repair is not feasible given the cost of justifying and gaining approval for the repair.

4.3 Competent Authority approved designs

The Guide To An Application For UK Competent Authority Approval Of Radioactive Material In Transport (IAEA 1996 Regulations) DETR/0003 January 2001 reference 2 gives guidance to applicants as to when and how to involve the UK Competent Authority in any modification to a package approved by them.

Key aspects and guidance given by the UK Competent Authority are as follows;

- modifications can be classified according to their effect upon safety of the package design,
- the procedure is intended to help prevent inadvertent invalidation of certificates due to alterations of package designs made without Competent Authority knowledge,
- a decision not to apply for prior competent authority approval for amendments and concessions is at the risk of the consignor,
- applicants are advised to discuss the need for approval with the competent authority for all but the most minor cases to avoid the risk of non-compliance with the terms of approval,
- request for modification approval should be accompanied by all supporting documentation. When approval is granted, a revised certificate of approval should be issued before the packaging can be returned to service. Approval to modify the packaging may be granted without the Certificate of Approval being amended dependent on the nature of the repair and the particular Competent Authority procedure.

The guide grades modifications and changes as follows;

- CATEGORY A: Major change to the package and/or the package design application directly affecting the assessed package safety, i.e. structural integrity, containment, shielding, heat transfer or criticality.
- CATEGORY B: Significant change to the package and/or the package design application not primarily affecting the assessed package safety.
- CATEGORY C: Minor change to the package and/or the package design application not primarily affecting the assessed package safety.
- AMENDMENTS
  Minor changes to documentation having no design or safety significance to the Applicants existing approval.

5 APPLICATION OF SQEP/QA/H&S

5.1 Introduction

This section defines in outline the QA and Health and Safety processes that are needed to effect a repair. It assumes that the owner of the packaging and any design authority/user/maintainer/repair organisation has the relevant QA accreditation and the scope defined in that accreditation includes the activities required by the repair.

5.2 Radiological Safety

Health Physics should produce a radiological protection plan to define any controlled area required, monitoring equipment and at what stages it is expected. The handling and disposal of any potentially contaminated waste shall also be considered.

If specialist repair is required it may be necessary to send the packaging (or a component) off site for repair. The repair organisation may or may not have a controlled area or a license for having radioactively contaminated items on site. If the repair organisation does not have the requisite licences and health physics staff, allowance shall be made for decontaminating the package or component. If there is any possibility of there being contamination remaining then provision shall be made for the attendance of Health Physics staff to monitor during disassembly and other key stages of the repair.

5.3 Conventional Industrial Safety

The processes for repair are likely to involve all or some of the following; lifting, machining, welding, fitting and may also involve use of chemical processes. The repair organisation should have risk assessments in place to encompass the expected industrial risks. Consequently any repair should be supported by a Health and Safety Plan with sign off by appropriate stakeholders.

5.4 Quality Assurance

Any repair should be supported by a Quality Assurance Plan with defined hold points and sign off at key stages. Hold points are likely to include;

- design approval
- repair plan preparation/application
- drawings supplied to repair organisation
- procedures in place for processes eg weld procedures/approvals
- in practice craftsmen have correct qualifications eg weld approvals/currency
- inspection and non destructive examination

Once the repair has been completed the records for the individual packaging need to be updated to include the details of the repair, materials and processes used, test results (eg leak, proof pressure or lifting test) with copies of route cards, material and test certificates placed with the Lifetime Quality Records.

Use of Suitably Qualified and Experienced Personnel (SQEP)
Repair processes may require input from several engineering specialists, typically;

- weld engineers/metallurgists
- Health Physics
- polymer chemists
- physicists for criticality/shielding

These personnel should have relevant experience to provide advice on repair of transport packagings.

Records
Packaging when supplied new will have been supplied with a Declaration of Conformity which is supported by design documents and build records.

Typically these would be;

- Design Safety report plus supporting calculations
- Type approval test reports and specifications
- Operating and Maintenance Instructions
- Detail drawings
- Material certificates
- Weld procedures/welder qualifications
- NDT test certificates (welds/leak and proof testing)
- DoCs for proprietary items(eg fasteners/shackles/seals)

These should be available from the Design Authority.

Note that Design Authority/Manufacturer and user may all be different organisations. Consequently, the design information and manufacturing information may be held by different organisations and a user may only hold sufficient information to operate the packaging.

Furthermore in the case of older designs the Design Authority may no longer exist and drawings and other design information hard or impossible to locate. In the case of companies that design and manufacture packaging they may have (or had) policies in place that preclude issuing design information since that is their Intellectual Property. In extreme cases if documents are unavailable the packaging may have to be scrapped.

Given that the information listed above is to hand then any repair scheme can then be based on real substantiated data, giving confidence that the repair will not adversely affect package integrity.

If that is not the case then a search for the information across several companies may be fruitful, but in light of recent experience with mergers/acquisitions and insolvencies, coupled with the fragmentation of government owned companies, this may be difficult.

If the information is not to hand, then prior to preparing a repair plan, dimensional surveys, sample material analysis and calculations to justify the integrity of the repair may need to be undertaken.

A Typical Repair Plan is attached in Appendix III.

6 REPAIR OF MAJOR COMPONENTS/SYSTEMS

6.1 Introduction

This section describes outline repair methods for major packaging components. Each section describes how a particular component may be repaired and where appropriate indicates how damage may have occurred.

The examples cannot be expected to cover every specific situation and consequently a generic approach has been adopted for key components of packaging. As far as possible real experience has been brought to bear on the methods described. Each repair will need individual consideration to take account of technical feasibility, economics and maintaining regulatory compliance and design intent.

6.2 Shielding

The principal neutron shielding materials are;

- Polyethylene (boronated/natural)
- Water extendable polymer (WEP)
- Boronated Aluminium (Boral)
- Boronated steel
- Boronated resin
- Boronated ceramics

For beta/gamma shielding;

- Steel
- Concrete
- Cast Iron
- Lead
- Tungsten
- Depleted uranium

These will be incorporated in packaging as either discrete components (easily removed or separated from the rest of the packaging) or as integral parts of the packaging (eg lead steel composite with the lead poured in and the packaging body welded closed).

Even as discrete components the material may be encased in a protective sheath, to protect it from damage or to prevent the shield material from contaminating its environment (eg lead will often be sheathed by stainless steel, paint or plastic in radio pharmaceutical applications).

As a discrete component, dependent on its size, replacement is likely to be more cost effective than repair. Where repair is deemed necessary the type of repair will depend entirely on the extent of the damage. Shielding is not normally subject to mechanical wear so any repair required is likely to arise due to damage whilst handling of the shield or packaging.

There are some limitations to repair methods due to the material properties and characteristics. Tungsten shielding is made from sintered material and would not be weldable, similarly there is little evidence that Boral can be welded. Damage to castable materials (concrete, resin, WEP, lead) should be capable of being repaired subject to being able to provide adequate control of the final cast shape using a moulding former.

Care should be taken to ensure that the bond between new and existing material is of similar strength to the original material and there may be a need to provide a surface finish or surface profile to ensure adequate keying of the new material.

Steel, including boronated stainless steel, can be welded and can be patched; welded joints will need joint preparations to ensure that weld material can be laid to achieve fusion. Care should be taken to ensure that heat and shrinkage do not cause cracks. Similarly foreign material, slag, other inclusions or porosity can give rise to cracks. The boron content may reduce in the area of the weld as weld metal is laid.

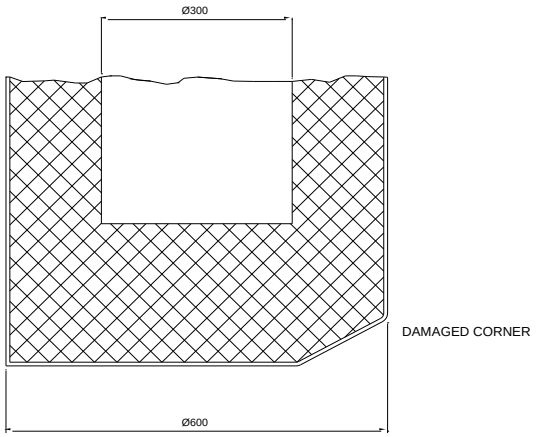
Should the repair of a lead/steel composite flask or sheathed lead be necessary to access the lead shielding, cold cutting methods only should be used to expose the lead (to prevent toxic fumes being created as the lead vapourises). Similarly during lead pouring the temperature of the lead pour should be kept to just above the melting point. Careful consideration should be given after the lead repair when closing/sealing the steel jacket with weld. The lead should be

cut back from the weld area (to prevent it melting, vapourising and contaminating the weld, since fusion could be compromised.

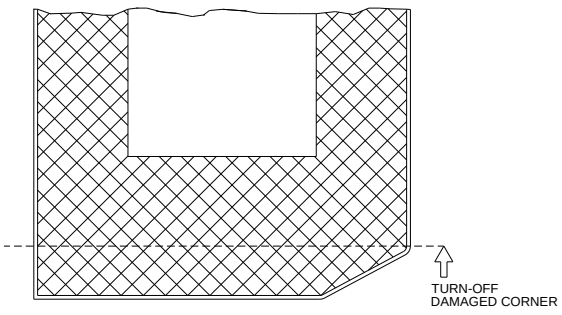
Repair of shielding components or remanufacture should be followed by verification of their shielding effectiveness by testing using a radioactive source, this is of particular importance when lead pouring or making good a shield by bonding in new material.

The following sequence diagrams show how a repair may be effected on a damaged lead/ steel composite flask.

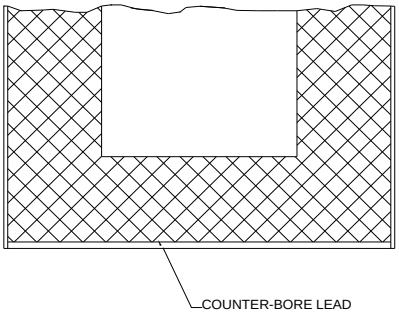
The flask has a damaged corner as shown below but no other damage.



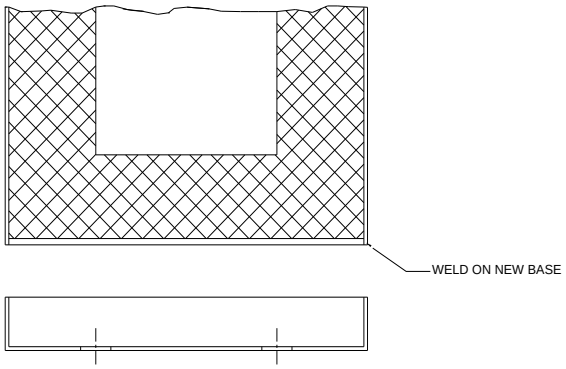
The damaged base may be turned off, back to an un-deformed area of the flask body.



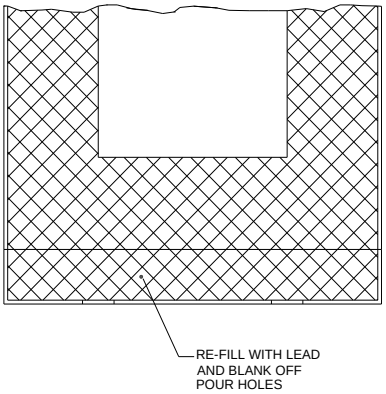
The lead should then be counter bored so that the area where weld is to be laid is not going to result in the lead melting and to ensure there is no lead contamination of the weld. Consideration should be given to profiling the lead surface to ensure keying of new lead. This would be particularly important if the lead was providing radial shielding.



A new base can then be welded in place and the weld examined.



Lead may then be poured into the cavity and the pour holes sealed.



6.3 Fastenings

Mechanical fastenings would typically include;

- bolts
- screws
- nuts
- studs
- rivets
- pins

made from a variety of metallic materials.

The need for repair/replacement would arise from wear, accidental damage (cross threading/impact) or loss.

In many cases simple replacement of the fastening can be made. Ensure that any replacements are correct size, material and strength/grade. It is likely that the designer would have tried to ensure that female threads in large components are not subject to wear by the use of studs. Where studs cannot be used it is normal to use thread inserts to protect the parent material from wear. The thread inserts can be replaced if necessary using proprietary kits.

Should the parent material having been tapped become worn then replacement by wire inserts would be acceptable subject to determination of pull out forces either by experiment or calculation. Also, where a long series of tapped holes are used there may be scope to drill and tap new holes spaced in between the existing holes and plug the redundant holes.

The hole could be drilled out and a new tapped plug welded in place with the weld ground flush. As a last resort if there is sufficient material in the joint design, the drilling out of the existing tapped hole and the fitting of larger threads may be possible provided that the integrity of the joint can be demonstrated. If the fastening is in a lifting load path or part of a pressure boundary (eg containment) then proof load or proof pressure tests should be performed before release back into service.

6.4 Containment

Containments can take several forms and could at their simplest comprise a simple plastic bag, vial, can or drum. Alternatively they could be engineered steel pots, steel pots integrated with lead or other shielding material. The extent of any repair will therefore depend on what the damage is and the ease of repair. The need for repair could arise from external handling damage or internal damage from the payload.In the case of a simple plastic bag, vial, can or drum, economic repair is unlikely to be viable.

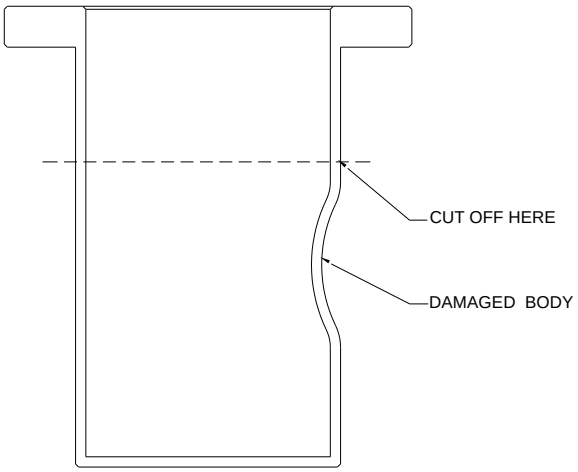
For containments that are directly combined with shielding, access may prove to be a problem particularly if the damage to the containment is internal and the containment and shielding cannot be separated. If access can be gained then dressing of scuffs, deep scratches or even laying down weld (with subsequent dressing back) could be considered for surface repair. Consideration should be given as to when the repair becomes structural and it might be suggested that any penetration of the surface that is more than 10-15% of the material thickness could be construed as a structural repair. If there is doubt then review of the design calculations should give guidance on the amount of material thickness that is needed to meet the structural requirements.

For cylindrical thin wall containments (<6mm) which are independent of shielding or any other part of the package, repair may be effected by cutting out and replacing tops or bases or even the middle. Patch repair of full thickness should be avoided due to the stresses and subsequent distortion that weld shrinkage could induce. The stresses can be eliminated by annealing (subject to size) but the distortion is likely to remain (particularly with stainless steel materials).

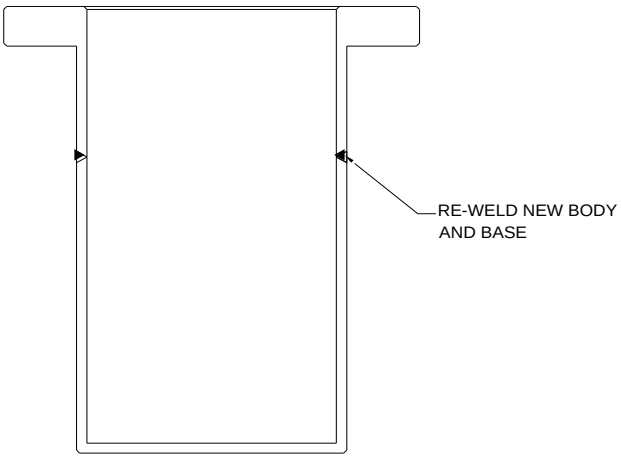
Where full penetration welds are used in the repair, the weld should be examined using a criteria and methods as applied to the original welds. Likewise proof pressure tests and leak tests should also be conducted to demonstrate that the original design intent has not been compromised.

The following sequence diagrams show how a repair may be effected, the damage is local and confined to a relatively simple part of the containment body.

Firstly the damaged area of the body is removed back to an un-deformed area.



A new base can be made and welded in place with welds inspected on completion.



6.5 Valves

Packaging designs may incorporate valves linking to the containment. These are included for a variety of reasons eg to enable sampling of the interior of the package prior to lid removal, to purge the interior or to enable the introduction of inert gas to ensure that the payload does not react with oxygen.

As the valves are generally for gas or liquid sampling they do not tend to be large items and repair of the valve itself would normally be uneconomic. Therefore replacement would be the most likely outcome. In some cases the valve housing is integral with the packaging body and the seal faces are part of that body, repair of seal faces here may require dressing or at worst re-machining. Larger valves may be encountered for the transfer of bulk liquids/ion exchange resins, but again replacement would be the most likely option.

6.6 Insulation components

Thermal insulation may take the form of discrete components that are easily removed from the packaging, or be integral with the packaging in the form of foamed/poured-in-place materials such as polyurethane foam.

Typical materials used are;

- resin bonded cork (eg Chingford 22)
- natural cork
- mineral board
- mineral wool
- wood (balsa, other soft or hardwoods egiroko)
- polyurethane foam (in both component and foamed in place configuration)
- WEP water extended polymer

Often the insulation will serve a dual function, WEP provides neutron shielding combined with a high specific heat due to its water content and when it burns it chars (providing further insulation). Similarly cork and other woods will provide impact mitigation and insulation.

Therefore when repairing insulation careful consideration should be given to ensuring both its insulation and its mechanical properties remain within specification.

Foamed or poured-in-place materials are likely to have been damaged together with their protective former/jacket, repair may not be economic, or practical. A patch weld repair on the former/jacket cannot easily be made without causing damage to the underlying insulation.

Discrete components may be repaired more easily; small items are likely to be remanufactured rather than repaired. In the case of larger items a patch repair should be possible. Where materials have a grain or their construction is such that their mechanical/thermal properties are anisotropic, then the repair patch should replicate this. Furthermore, the patch will require careful fitting to ensure that bonding is complete and not glue or resin rich.

Intumescent coatings and strip materials can also be used to protect vulnerable areas of the packaging. Intumescent strip, if damaged could be repaired locally with a section replaced, coatings will need to stripped backed to sound undamaged material and then reapplied in accordance with the manufacturer's instructions.

6.7 Seals and seal faces

Seals used on radioactive material transport packaging are used largely for either keeping weather/water out or on the containment boundary - both are important, keeping the weather out will prolong the life of the packaging and the containment boundary seal is a key safety feature. Leak test points also incorporate seals/sealing faces and whilst failure will not usually compromise package integrity a leak here is undesirable and inconvenient at best.

Seals on the containment boundary are likely to one of two types, elastomeric or metal. The seal geometry will vary from a simple O ring to complex sections custom made for the application. The seal face and seals are a major component that will be subject to wear and damage due to relatively frequent use. The seal face on the body of a packaging may also interface with a process cell as well as the lid. Whilst designers will try to configure the geometry to minimise the opportunity for damage to either the seal or its mating faces some damage is inevitable.

Elastomeric materials have a finite life and maintenance instructions will usually call for their replacement on a regular basis particularly if they are simple standard O rings. Consequently repair of the seal is not likely.

Seal faces are a different matter, careless handling can result in damage to the lid or the body of the packaging in question. The removal and replacement of the payload may also cause damage. This will normally take the form of small scratches, dents, gouges, the method of repair will depend on the nature of the damage. Shallow scratches can often be dressed out when the depth is less than 10% of the compression of the seal. Significant gouges or damage may require re-machining of the face. Whether this is possible or not will depend on several factors;

- is there sufficient material remaining to allow re-machining of the face without reducing strength?
- can the item be shipped to a facility for machining (the presence of contamination may preclude this if it cannot be removed)?
- is it economic?

Once a repair has been completed then leak tests (and if specified proof pressure testing) can be performed to ensure that the integrity of the packaging has been restored.

6.8 Cracks/weld repairs

Cracks in the structure of the packaging can arise for several reasons;

- Mechanical damage (usually visually detectable)
- Over stress
- Distortion of a large structure
- Fatigue (usually related to vibration)
- Defects in the original weld
- Corrosion
- Defects in the original material
- Presence of hydrogen

Most of the cracking described above may well be hidden by dirt/ grime or paint and will not always be accompanied by visually detectable indications. Equally cracks in paint may not always be accompanied by cracks in the underlying material. If in doubt simple NDT weld examination should detect the presence (or otherwise) of cracks.

Once discovered an assessment is required as to the likely cause since there may be a design or manufacturing defect, the loads imposed on the packaging have changed or been exceeded, or an abnormal event has occurred. Any paint or finishing system around the affected area should be removed and an appropriate crack detection/measurement method should be used to determine the extent of the crack, the method used will depend on the material, ultrasonic methods will normally reveal the extent of the cracking, and reveal any existing defects such as inclusions/porosity.

To effect a satisfactory repair consultation with a weld engineer is recommended to advise on the process. A weld repair could, if not executed with care, result in more damage and cause crack propagation. Section thickness, material and geometry will need consideration as will any extent of grinding out of the defect, preheating, weld preparation, type of weld process used and any subsequent heat treatment.

It is possible that the weld repair can be performed on the site where the packaging is kept, since weld sets are portable. However hot working in controlled areas requires risk assessments and permits to work.

Once repaired then the weld should be inspected (in conjunction with proof testing, if specified) and the finishing system made good.

6.9 Cosmetic damage/corrosion

Paint and plated finishes have a finite life, which may, during the life of a packaging need to be replaced or reapplied. In the UK in particular many nuclear sites are adjacent to the sea, where the presence of salt combined with wind can result in finishes needing cosmetic work regularly. Besides the marine environment, industrial atmospheres can be acidic and again shorten the life of a finish.

Corrosion may also be initiated by contamination with other materials, eg the use of carbon steel lift gear in contact with stainless steel.

The above in combination with general handling damage, scratches, dents and chipped edges/corners caused by lifting gear/ fork lift tines will inevitably result in corrosion.

Minor surface corrosion (particularly of thicker materials) will not usually affect the integrity of the packaging and may be acceptable. It should be recognised that significant corrosion in areas which may become contaminated may hinder monitoring and any subsequent decontamination. Once the above is taken into account it is then a matter of judgement as to whether repair for purely cosmetic reasons is required. Reasons for cosmetic repair, whilst being subjective would be influenced by company policy regarding presenting a tidy and professional image. The nuclear industry succeeds as a whole to present a professional image and transport packages operate in the public domain and this should be reflected in their condition.

Typical finishing methods would be;

- Plating

- Hot dip galvanising
- Painting

The method of repair/retouching will depend on the extent of the damage, the finish and the material being protected. In all cases the surface corrosion must be removed and all loose or flaking coatings taken back to sound material (usually by mechanical abrasion). Small areas may be satisfactorily cleaned/abraded using hand or power tools, but a large area will usually require shot blasting.

The presence of corrosion, which may initially be assessed as superficial, may hide other problems, such as cracks or deep pits which may affect the structural integrity of the packaging and therefore deeper investigation using NDT techniques may be called for.

Plating will tend to have been applied to components, (although larger structures may have been hot dipped galvanised).

Damaged plating on components can be replaced by stripping and re-plating if necessary, however it is probably more cost effective to replace the component. Care should be exercised with lifting gear (shackles, chains) and fastenings (particularly in critical applications such as lid bolting/attachment of tiedown/lifting features), since corrosion may have caused cracks and weakened the item.

Hot dipped galvanised fabrications may be repaired by locally coating with zinc solder (which requires heating the area to 315^{o}C). Alternatively molten zinc or zinc rich paint can be sprayed on the affected area.

Where paint requires reapplication the method of application will depend on the paint manufacturer's recommendations. Small areas will normally be brush painted, but roller or spray are more appropriate for larger areas.

During the repair the thickness of the coating should be established to ensure that it meets specification.

6.10 Dents/distortion in structure

Dents, gouges or distortion of the packaging structure will accumulate over time. Whether they are acceptable to leave unrepaired or not will depend on the degree of damage and where the damage is.

Whilst the package may not be subjected in service to the forces imposed during the testing for Type Approval, any damage to the structure could induce a failure if those forces (or even lower forces) were applied. A packaging having suffered such damage should be repaired, because the resistance of those forces during the Type Approval testing is used to demonstrate the packaging's compliance with the regulations.

For example should the vertical corner post of an ISO freight container become bent or severely dented then this damage, if not repaired, could result in a buckling failure if the stacking forces were applied.

Dents or distortion could also reduce the ability of an impact limiter to perform as designed. This damage may cause the impact limiter to collapse in an uncontrolled manner in an impact and as a result subject the package to higher decelerations than it was originally demonstrated to withstand.

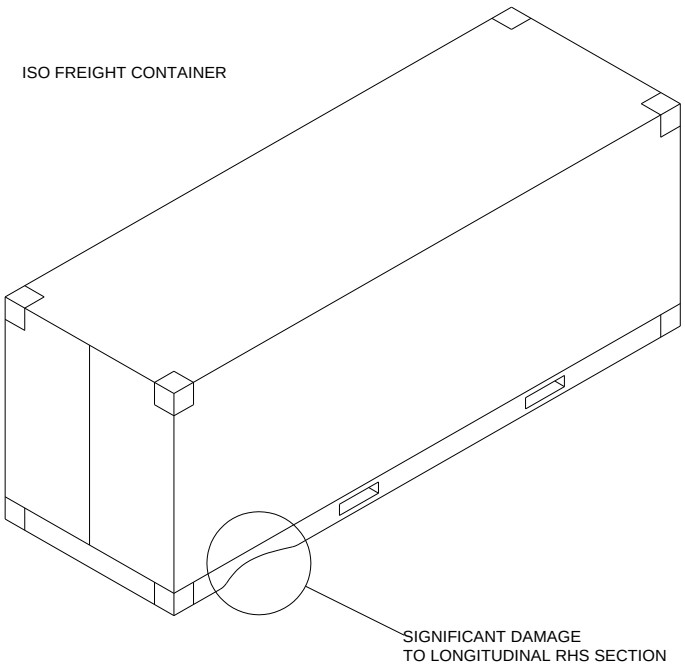
Repairs should be made such that the design intent is maintained and these are likely to involve the fabrication of patches and welding.

Structural steel members such as SHS/RHS can have the damaged area cut out and patched, if the damage is on two adjacent faces then an angled plate can be fabricated. Any repair patch should replicate the section being repaired.

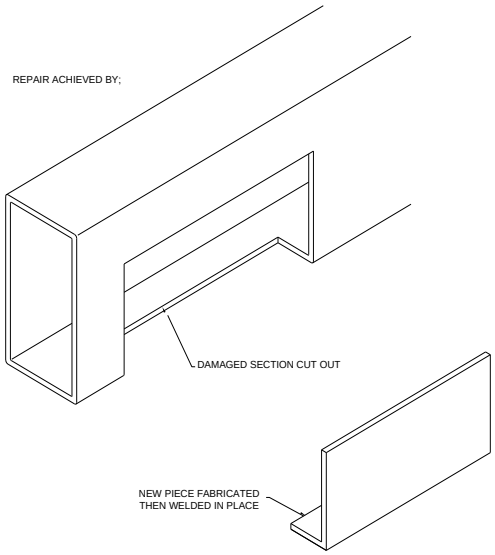
Dents or distortion may also affect thermal properties in that air gaps or surface area may be reduced, or in severe cases closed so that there are direct conduction paths. Repairs should be made, because the packaging will no longer perform as the specimen did during the Type Approval testing.

Minor dents or gouges (particularly in thinner skins) will not usually affect the integrity of the packaging and may be acceptable. It is then a matter of judgement as to whether repair for purely cosmetic reasons is required. Where possible dents should be pushed out, if the dent is such that significant yielding has occurred it is unlikely that the material will return to its original profile and patch repair should be considered. Filler material may be used for cosmetic repairs if a smooth surface is required to aid decontamination. The use of filler should be minimised to avoid hiding future deterioration.

The following sequence diagrams show how a repair to a structural section on a Freight Container was effected. The container had significant damage to its bottom rail.



The area of damage was cut out, prepared for welding by removing all corrosion and paint in the area of the weld, a new piece fabricated, and then welded in place. The weld repair was approved by Lloyds Register, and subject to NDT post welding.



6.11 Lifting /tiedown features

Lifting and tiedown features are important for general industrial safety as well as transport safety and sometimes a feature will be used to both lift and tie down. Lifting/tiedown operations involve the regular attachment and removal of equipment and cosmetic damage is inevitable usually in the form of small dents and paint damage. Furthermore, tiedowns can be susceptible to fatigue due to vibration during transport.

Designers use well proven CoPs and standards, which demand high factors of safety and proof testing at build, in order to take account of handling and snatch loads. However, mishandling, the use of incorrect equipment, or shallow sling/tiedown angles can result in overstressing.

The maintenance instructions should indicate what damage/faults to look for at maintenance and these would typically be cracks or distortion perhaps in the form of weld cracking or elongation or bending of lugs.

Repair may be reasonably straightforward, but because of the potentially high stress (the components may have been made from forgings and consequently repair may not be possible since the grain flow cannot be replicated)replacement may be the only option. Lifting trunnions are usually designed to be unbolted, although some older designs may use welded components.

Eyebolts may be replaced where used but care should be taken to ensure they are aligned correctly.

On the conclusion of any repair a proof load test will be required (usually with pre and post-test NDT).

REFERENCES

1 The Regulations for the Safe Transport of Radioactive Material, IAEA Safety Standards Series No. TS-R-1 2009 Edition.

2 Guide To An Application For UK Competent Authority Approval Of Radioactive Material In Transport (IAEA 1996 Regulations) DETR/0003 January 2001.

Appendix I - List of Standards

This section lists those standards that are relevant to repair and include TCSC standards (pertinent to repair/inspection only) and international standards for processes such as welding. It is not an exhaustive list and the Design Authority for the packaging would be expected to have detailed knowledge of the other standards that encompass the materials and processes used in the original manufacture of a packaging.

TCSC Documentation

TCSC	Title	Issue in Use
1042	Design of Transport Packaging for Radioactive Material	December 2002
1056	Shielding Integrity Testing of Radioactive Material Transport Packaging	December 2005
1068	Leakage Tests on Packages for Transport of Radioactive Materials	March 2008
1080	Finishing systems for Transport Containers	June 2010
1088	Surface Finish Guide for Transport Containers manufactured from Stainless Steel	March 2008
1090	The Design, Manufacture, Approval and operation of an ISO Freight Container for use as an Industrial Package Type 2 (IP-2)	March 2009

British and ISO Standards

The following welding specifications may be useful since they are for weld procedures, welder qualifications and non-destructive examination, note they do not encompass defect criteria.

- Qualification test of Welders Fusion welding Part 1Steels; BS EN 287-1:2011
- Specification and qualification of welding procedures for metallic materials. General rules BS EN ISO 15607:2003
- Specification and qualification of welding procedures for metallic materials Welding Procedure Test PART 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys. BS EN ISO 15614-1 2004 +A2:2012
- Non-destructive testing of welds. Magnetic particle testing BS EN ISO 17638:2009
- Non-destructive testing of welds. Ultrasonic testing. Techniques, testing levels, and assessment BS EN ISO 17640:2010
- Non-destructive examination of welds - Radiographic testing of fusion-welded joints ISO17636 : 2003

Appendix II- Example Concession

APPLICATION FOR A Concession		Page 1 of 2
1) **Addressee**	2) **Contractor**	3) **Supplier**
4) **Work Package No.**	5) **Order No**.	6) **Supplier No**.
7) **Description of Material or Component**		
8) **Specification Drg/Part No. Issue/Ser No (as applicable)**	9) **Ref. No. of Concession/Production Permits previously granted**	
10) **Description of Non-Conformance (and proposals for recovery if any):**		
11) **Reason for Application:** Reduce Production Costs ☐ Specified Material not Available☐ Error in Manufacturing Data ☐ To accommodate Local Manufacturing Methods☐ Manufacturing Error ☐ Other reasons:		

12a) **Originator**	12b) **Supplier**
Submitted by …… (Block Capitals)	Submitted by …… (Block Capitals)
Signature ……	Signature ……
Position Held ……..	Position Held ……..
Date ……..	Date ……..

13) **Comments by Quality Control/Quality Representative of Originating Area**	14) **Distribution**
Name (Block Capitals) ……	
Signature …… Date ……	

15) **If this application is granted are any of the following adversely affected** (if YES please clarify below)

ENVIRONMENT, HEALTH or SAFETY YES / NO	STRENGTH YES/NO	LIFE of ITEM YES/NO
INTERCHANGEABILITY YES/NO	MAINTENANCE YES/NO	FUNCTIONALITY YES/NO
CUSTOMER YES/NO	COST YES/NO	DELIVERY YES/NO

Name…….. Position……. Signature …….. Date: …….

16) **Design Authority Decision**

Implementation required by (Date)……

Name…….. Position……. Signature …….. Date: …….

17) **Approval Authority (Competent Authority / 3rd Party)**

YES / NOComments

Organisation ……..

Name…….. Position……. Signature …….. Date: ……

Appendix III - Example Repair Plan

STUD REPAIR GUIDANCE DOCUMENT

Summary

Subject to the foregoing this Guidance Note should be read in conjunction with the Packaging Operational Documentation.

Notwithstanding any other term of the Guidance Note, this Guidance Note is intended only to support the container Design Operational Documentation by explain the basis of the condition requirements and providing additional information. Nothing in this Guidance Note shall be legally binding upon the Operator of the XYZ Company Ltd and all Terms and Conditions between such Operator and the Customer for the repair of Studs. In the event of any conflict between the provisions of the Guidance Note and any Stud Repair Conditions, the Container Design Approval Conditions shall prevail in all respects.

Issue Number		1
Issue Date		
From	To	
	Until	Reviewed
Prepared by		Engineer XYZ Company Ltd
Checked by		Senior Engineer XYZ Company Ltd
Approval by		Engineering Director XYZ Company Ltd

INTRODUCTION

This document has been prepared to provide guidance on XYZ Company Ltd's Sheared Stud Repair and Replacement requirements.

PART A General Requirements

A1 Any repairs including stud replacement should be pre-authorised on submission of a repair concession.

A2 Request for repair concession shall be made to the XYZ Company Ltd Transport Team. The operational inspection authority will raise the concession on the customers' behalf and will require details of:

A2.1 Weld procedure
A2.2 Welder Qualification
A2.3 NDT Technique Sheet (only required for Level 1 Operator)
A2.4 NDT Operators Qualification

A3 The Design Authority will review the concession application and subject to approval will authorise the repair.

PART B Procedure for Sheared Stud Replacement

B1 Replacement studs to be obtained from the XYZ Company Ltd

B2 This procedure should be followed when replacing a sheared stud.

B3 Determine area to fit the new stud (recommended position to be approximately 50mm from the edge of the weld of the failed stud).

Note:- The old stud is not to be refitted but to be returned to the XYZ Company for examination (if deemed necessary) or discarded.

B4 Remove paint approximately 80mm diameter around the area where the new stud is to be fitted (to allow subsequent testing of the weld and Heat Affected Zone – HAZ).

B5 Weld the new stud in accordance with the approved weld procedure.

B6 Carry out Dye Penetrant Inspection of the weld and HAZ. (Acceptance Criteria – Zero indications).

Note:- Ensure surface is thoroughly cleaned on completion

B7 Carry out soap bubble test under vacuum test to the old stud position, the new stud position and HAZ in accordance with an approved procedure (Acceptance criteria – Zero bubbles).

B8 Carry out pressure test to the adjacent orifice seal interspace in accordance with XYZ Company Ltd procedure.

B9 Make good the paint at the repair.

B10 On satisfactory completion of the repair and testing, a report/reports shall be raised covering repair, NDT and pressure testing. Copies should be submitted to the T&L Team.