
ANECDOTAL INSTALLATION AND COMMISSIONING PROBLEMS

2.0 RAF Cottesmore

2.1 Background

- a. Low IR's were reported on the approach lighting systems at 23 runway end on circuits installed in 1996. Tim Booth of 'Interserve' requested LPA at DE Sutton Coldfield to investigate the cause and examine possible solutions.
- b. Four TISE's were removed from service as suspect and returned to the manufacturer for inspection. The TISE's were returned to AWE, three of the units were returned with primary joints on at least one leg and one unit was returned without any joints attached. A copy of the test results is attached.
- c. The results of the tests showed that the joints used to connect the TISE's to the network were the cause of the low IR's. Failure of the primary water seals and migration of water along the earth bonds resulted in water ingress causing low conductor to earth IR's.
- d. There is a dispute over the identity of the joints; 'Interserve' contends that no joints were returned with the TISE's and that therefore the tested transformers were not those removed from the ground.
- e. Examination of two TISE's returned to DE from AWE showed the transformers had been returned with straight joints attached to the primary TISE cables. These joints do not have the external earth bond and are intended for non armoured to non armoured cables such as TISE primary leads. This fits the contention from 'Interserve' that none of the bonding joints were returned and that they were cutting the leads in front of the bonding joints testing and then re-connecting.

2.2 Preliminary Investigation

- 2.2.1. The joints used on the approach lighting system at RAF Cottesmore were supplied by 'Shrink Polymer Systems' as suitable for jointing armoured to non armoured AGL cable with an external earth bond.
- 2.2.2. Examination of the jointing instruction showed a number of deficiencies in the design. However, the deficiencies are such as to make the joints overly sensitive to dimensions and assembly error rather than make them specifically unsuitable for the purpose intended. A site inspection also showed that the installation of the remote end of the earth bonds was in itself a primary cause of moisture ingress.
- 2.2.3. Examination of the joints returned with the TISE's from AWE showed that they had not been made in accordance with the manufacture's instruction. The black sealing mastic had not been applied to the connector/primary insulation. Therefore any water under the sheath of the primary tails due to a faulty bonding joint would have immediate contact with the conductor.

- 2.2.4. It was also noted that the outer protection heat shrink had not been evenly shrunk. One side of the tube was fully recovered while the other side showed minimal to zero recovery. This can only be attributed to a lack of heat and therefore the hot melt adhesive would not have activated. (See photographs appendix 1). On one of the returned joints the outer sheath had not been removed and had been cut flush with the insulation removal position.
- 2.2.5. Figure 1 shows the joint assembly supplied for the approach lighting system; listed below are the areas of weakness.
- a. The earth bond comes within the primary connector water seal; therefore any water migrating along the earth wire has direct access to the connector if the seal fails.
 - b. The assembly of the earth bond described in the jointing instruction can compromise the clearances between the end of the earth bond and the connector.
 - c. The joint should be considered 'wet' until the end of the armours, as there is no water blocking under the sheath; therefore any sheath damage will result in water migration along the length of the cable. The dimensions given for the removal of the armours does not allow any margin for error especially coupled with point 2.2.4 b.
 - d. A joiner working in the field would generally be expected to work within +/- 5mm, the length of core insulation available for sealing is therefore inadequate. *See Figure 2*
 - e. The use of a pre insulated connector makes it unlikely that the sealing mastic would be in contact with the conductor or insulation cut. If the connector is butted to the insulation this leaves an air filled void at the interface between the connector insulation end and the insulation cut which is unlikely to be sealed by the mastic. The dimensions given in the instruction would leave the connector butted to the insulation, although the drawing shows a gap.
 - f. The use of stranded earth wire for the external bond creates a 'pipe' to the inside of the joint. If the external end of the earth wire is not sealed any water in the ground will be drawn into the joint. *See point 2.2.4 a and Figure 3.*
 - g. The SPS joint was approved by the PSA in January 1991 and is a copy of a 'Sigmaform' joint. No documentation presented, if any, to support the approval has been found.
 - h. The joints were purchased in good faith and assembled in accordance with the instructions.
 - i. The use of stranded PVC covered earth wire for an external bond, while ill advised, does not constitute a failing on the part of the installer, as there is no guidance in the jointing instruction only a note to the effect that the earth lead is not supplied.

- j. Reference point 2.2.7, SPS can reasonably claim that a joiner should know to seal the end of an open earth bond that is buried below ground.
- k. Reference point 2.2.8, conversely the installer can claim that the joiner must assume that the internal seals are adequate in the absence of any guidance, and that the diagram supplied with the jointing instruction clearly shows a covered earth wire.

Management of Visual Aids at Military Aerodromes.

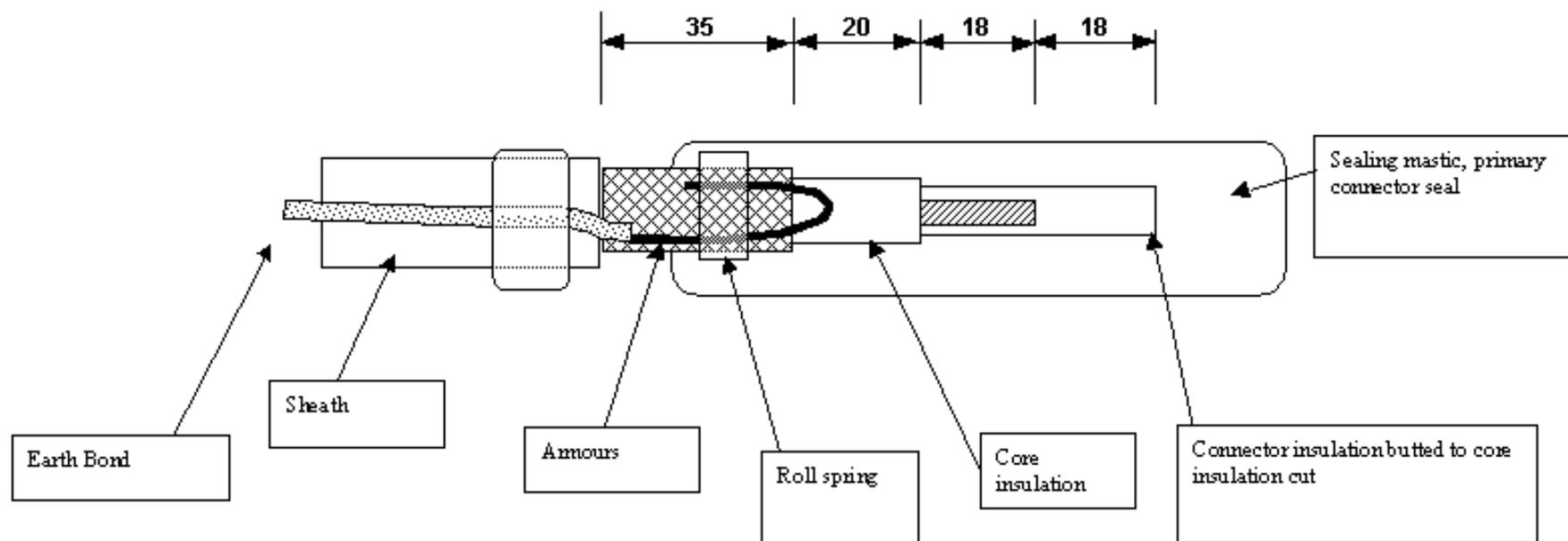


Figure 1; Dimensioned as drawn on jointing instruction. Outer heatshrink sleeve not shown.

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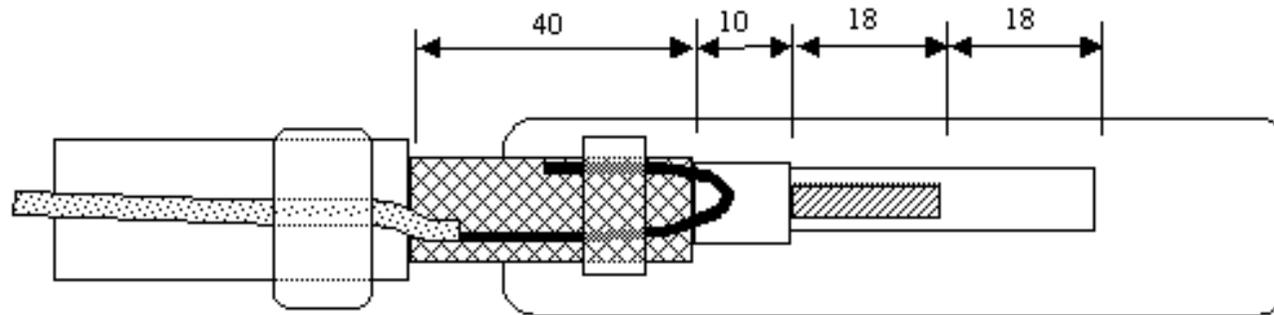


Figure 2. Drawing showing 5 mm error to two dimensions.

Typically a straight joint would be cut at the centre line and the sheath removed to the sum of the dimensions shown on the drawing.

After removal of the sheath the armours would be removed and then the insulation cut back for fitting of the connector.

On the above drawing the sheath has been cut back 5 mm short and the armours 5 mm long, this reduces the insulation cut back to 10 mm due to the need to fit the connector equidistant either side of the centreline. The requirement to bend the earth wire back and incorporate it into the spring will further reduce the length of primary insulation available for sealing. Although the instruction specifies the spring position 15 mm from the sheath cut it is most likely to be fitted at the end of the armour cut. In the above case there would only be approximately 5 mm of primary insulation available for sealing after the bend in the earth wires.

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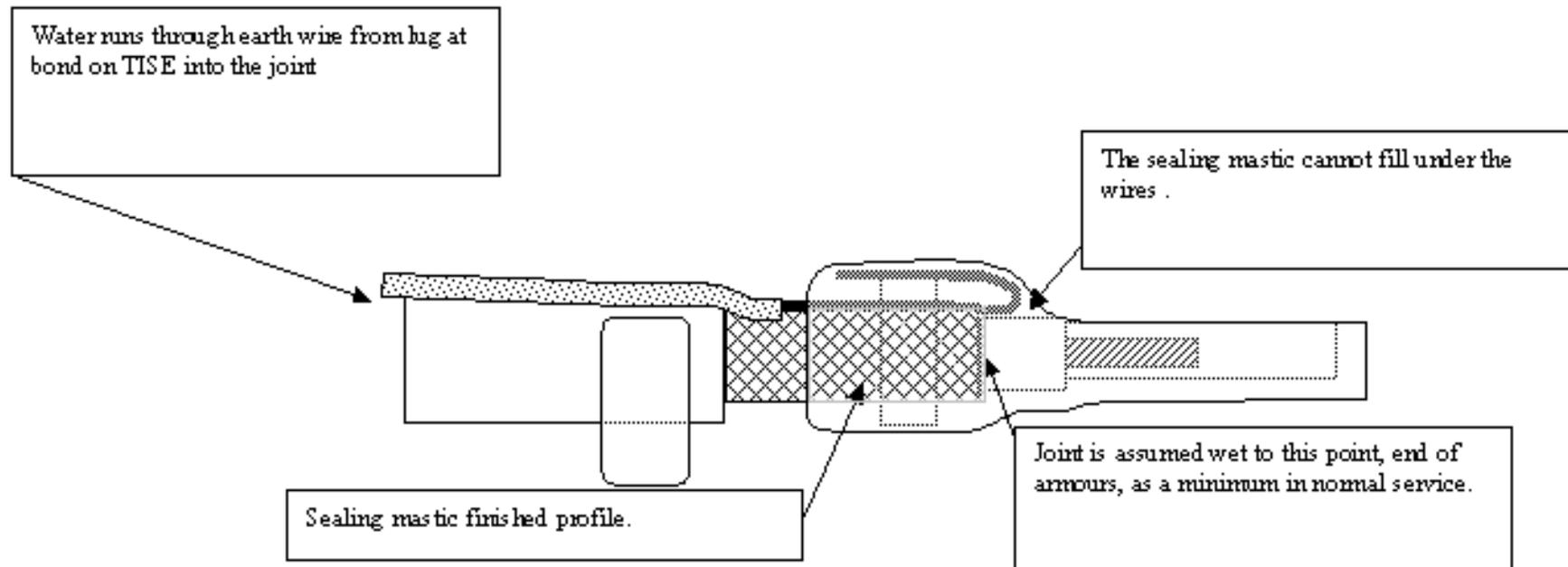


Figure 3. Joint assembly ,Figure 2, shown in profile.

The outer heatshrink sleeve will follow the same profile as shown for the mastic at the end of the earth wire. The sealing mastic will not seal the earth wires nor will it seal onto the primary insulation under the bend in the wires. As well as water migrating along the earth wire into the joint, any sheath damage will result in water migrating to the end of the armours. The bond of the sealing mastic to the primary insulation will be relatively weak in the first 5 mm after earth bond, as the recovery of the heatshrink outer will follow a catenary, the low pressure seal coupled with load cycling will not withstand water at 1 m head for very long.

2.3 Discussion.

- 2.3.1. The joints as supplied, if made accurately to the dimensions shown and if the external earth bond is sealed, and the cable sheath is undamaged, would probably perform adequately. However evidence from circuit IR's indicate that this is not a common occurrence.
- 2.3.2. Should any of the above fail to be true the performance of the SPS joint will be unsatisfactory. In addition the SPS joint would be unlikely to comply with the latest relevant BS specifications.
- 2.3.3. There is currently no specific British or International standard for AGL joints nor is there an MOD performance specification. There is also a question as to whether AGL joints should be classified as low or high voltage. Although AGL systems are generally constant current, technically as the AGL systems in use on UK military aerodromes have a maximum system voltage of 1950 V ac they could be classified as high voltage according to BS 7671:2001,. Furthermore; existing AGL cable used on UK military aerodromes are generally constructed to insulation levels suitable for 1.9/3.3kV systems.
- 2.3.4. If AGL joints are classified as low voltage, BS6910:Part 1: 1988 would be the most appropriate standard at the time of installation. However, AGL cable falls outside the scope of the definitions in clause 2 and classification of joints and cables, clause 3.
- 2.3.5. BS 6910 Part 1 clause 5.4.2 specifies a minimum of 30 mm overlap of heatshrink on the primary insulation either side of the connector as re-insulation. This is before any re-instatement of the outer sheath which requires a second piece of heatshrink, BS6910:Part 2: 1989, clause 4.3.2.
- 2.3.6. While the above standard may not be considered directly applicable, the requirements for design overlaps and construction mean that the SPS joint would not comply with the LV joint standard.
- 2.3.7. If AGL joints are classified as high voltage, BS7888: 1998 which applies to both low and high voltage joints would be the most appropriate standard today. This standard does not include any specific design or construction detail, but does provide an extensive test regime.
- 2.3.8. *However BS 7888 is very specific as to the cable standards and does not cover AGL types and excludes 1.9/3.3 kV cables/accessories from the scope of both the LV and MV Test requirements.*
- 2.3.9. Referring to point 2.3.3; AGL circuits could be designated as high voltage and be tested as such. However, the appropriateness of some parts of the high voltage test regime in BS7888 are questionable when applied to AGL joints. Therefore the standard test regime would need to be slightly modified. However, while AGL cables and joints are not within the scope and definitions of

BS7888 this would be the most appropriate standard for compliance.

2.4 Recommendations

- 2.4.1. The joints on the Runway 23 approach should be replaced with a more robust system.
- 2.4.2. The installing electricians/jointers should undergo manufactures training on the selected jointing system. The failure to assemble the straight joints correctly and the poor heat shrinking show that at least some refresher training is needed.
- 2.4.3. The electricians/jointers should be supplied with appropriate gas torches:

SPS 201 or SPS 202 gas torch kits are available and are suitable for heatshrink application and are available from.

Shrink Polymer System
Unit P1-P3 Grovemere Court,
Bicton Industrial park,
Kimbolton,
Cambs.
PE28 OEY.

- 2.4.4. All joints on the affected circuits TISE's should be removed and replaced.
- 2.4.5. In order to monitor the success of the replacement programme the circuit IR's should be measured and recorded on a monthly basis for at least six months.
- 2.4.6. Subsequent to this investigation SPS have improved the design of their AGL joints for DE and the following joints are now available and can be used to replace the existing joints.

2AGL1: TISE cable to armoured primary AGL single core cable with external earth bond.

2AGL2: Single core armoured primary AGL cable to single core armoured primary AGL cable.

2AGL3: Single core primary AGL cable without armour to Single core primary AGL cable without armour.

The above joints can be purchased from:

Shrink Polymer System
Unit P1-P3 Grovemere Court,
Bicton Industrial park,
Kimbolton,
Cambs.
PE28 OEY.

Tel:01480 861001

The following alternative AGL joints can be obtained from.

Tyco Electronics
Energy Division,
Faraday Road,
Dorcan,
Swindon,
Wiltshire.
SN3 5HH

Tel: Graeme Currie on 07802 587878

SMOE 81963: TISE cable to armoured primary AGL single core cable with external earth bond.

SMOE 81964: Single core primary AGL cable without armour to Single core primary AGL cable without armour.

SMOE 81965: Single core armoured primary AGL cable to single core armoured primary AGL cable.

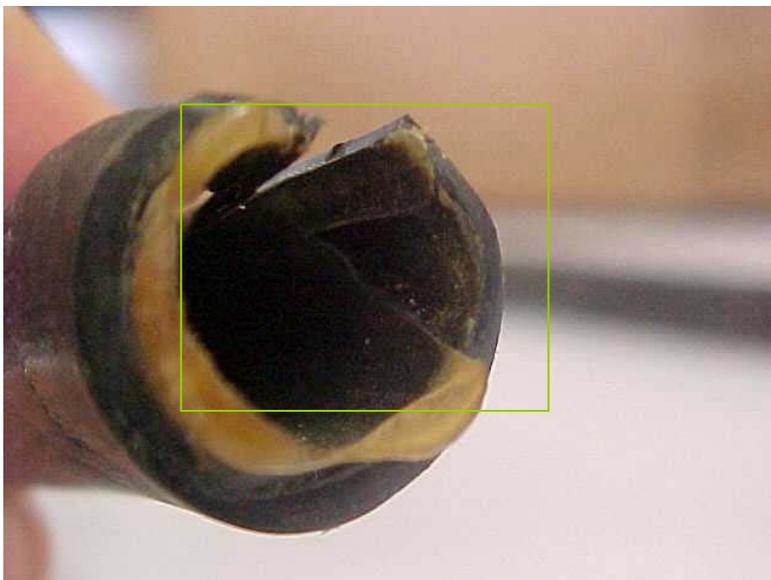
- 2.4.7. It is apparent from the IR data gathered during bi annual inspections that the defence estate has a significant problem of low readings on relatively young circuits. It is recommended that consideration be given to the production of a business case to conduct a deeper investigation into the issue of low IR readings. Much of the current spend on replacement AGL cables could possibly be avoided if it is found that the cable joints are the predominant cause.
- 2.4.8. If funding for a deeper investigation is forthcoming and the cable joints are found to be the primary cause of low IR's consideration should be given to pressing for the production of a standard specific to AGL joints.
- 2.4.9. In the immediate term the joints used on the Defence Estate and the training given to installers need to be more closely specified.

2.4.10. Appendix 1

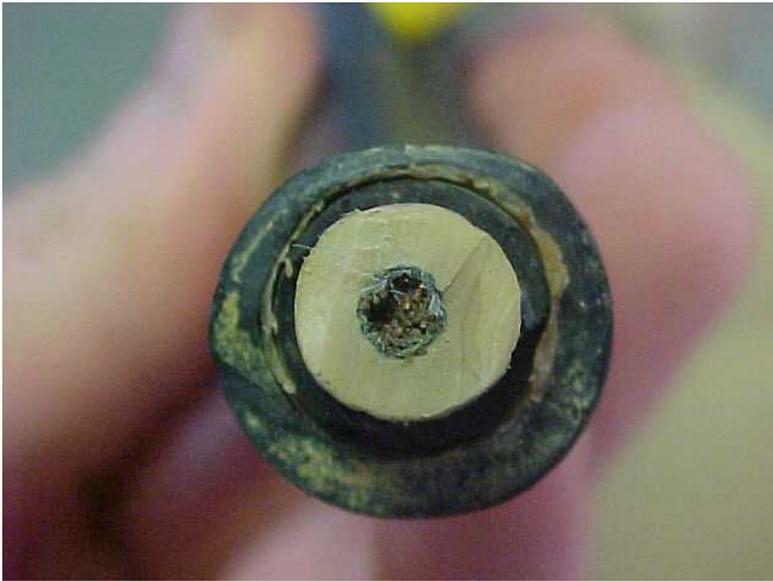
Photographs of faulty straight joint attached to TISE's removed from RAF Cottesmore.



Picture of connector showing no evidence of black sealant and outer sheath intact at insulation cut.



Picture showing hot melt adhesive that has not flowed, in green square.



Picture showing non uniform shrinkage.

2.5 Post Refurbishment

2.5.1. HIA 23 Installed in 1986 (All joints and some transformers replaced in 2002)

2.5.2. Prior to the refurbishment project, Mr Paul Mursell provided training and instruction in the correct jointing techniques to be adopted on all AGL Series Circuits as defined in Technical Bulletin 02/13.

2.5.3. Scope of Works

In order to provide a limited approach pattern only one of the interleaved circuits was decommissioned for refurbishment works. The works involved excavating all transformers and joints in order to replace all joints and transformers, which failed the soak test.

Initially 20 transformers were purchased (sufficient to replace the largest crossbar) which were installed and the existing removed to undergo a soak test. Those that passed were used as replacements for the next bar and so on.

All cable was tested in accordance with the guidance in the Technical Bulletin and replaced if the insulation resistance was not met or there was visible signs of damage. In addition the cable on all the crossbars was replaced as a matter of course, due to the short lengths concerned after the transformers and joints were cut out.

Table 1 below gives the AGL circuit insulation resistance data taken from 2003 airfield inspection report.

TABLE 1 AGL CIRCUIT INSULATION RESISTANCE – Data from 2003 Airfield Inspection Report

Notes: 1. Ground conditions during the Inspection were damp during the testing process following overnight rain.

Circuit Reference B1a Centre	Date of Installation	Site Log Book Insulation Resistance (M Ω)							Maintenanc e Datum Value	Safety Datum Value	Inspector's Insulation Test Value	Comment
		1997	1998	1999	2000	2001	2002	2003	(M Ω)	(M Ω)	(M Ω)	
23 HIA Circ. 1	1996	-	0	0.5	0	0	1600	-	53	0.13	Not tested	Satisfactory
23 HIA Circ. 2	1996	-	0.09	0.08	0	0	1500	-	53	0.13	Not tested	Satisfactory
PAPI (Port)	1982	1.04	3.0	5.5	3.0	10	20	-	152	0.065	Not tested	Below Maint. Datum
PAPI (Starboard)	1982	6.04	10	5.8	3.0	2.0	2	-	145	0.065	0.17	Near Safety Datum
Threshold 23	1996	-	Inf.	600	42	13	20	-	200	0.065	Not tested	Below Maint. Datum
HISL 23	1996	-	Inf.	100	1.5	2.0	2	-	28	0.195	Not tested	Below Maint. Datum
HISL 05	1996	-	Inf.	Inf.	16	60	50	-	28	0.195	19	Below Maint. Datum
Runway End 05	1996	-	38	4.1	0.6	1.4	1.2	-	283	0.065	Not tested	Below Maint. Datum
LISL 23	1996	-	400	170	90	Inf	Inf	-	38	0.065	Not tested	Satisfactory
Taxitrack TT5	1980	-	-	-	0.4	1.0	1.0	-	56	0.06	1.57	Near Safety Datum
Taxitrack TT6	1996	-	-	-	12	26	20	-	53	0.06	Not tested	Below Maint. Datum
Taxitrack TT7	1996	-	-	-	85	Inf	Inf	-	63	0.04	Not tested	Satisfactory
Taxitrack TT8	1996	-	-	-	70	23	20	-	58	0.04	Not tested	Below Maint. Datum

Table 1

B Centre B1a - 15.6KVA CCR's Circuit Reference

