IECEx SFC 03-5 Service Facility Assessment Training Guidance

John Allen
Sheppard Engineering Ltd
EASA Representative

Ex SFC Meeting Singapore
2024-03-04

International Electrotechnical Commission

IECEx SFC 03-5 Service Facility Assessment

Independent 3rd party service facilities do not operate as manufacturers, as a result auditing of service facilities has to be conducted differently

Manufacturers control product quality by controlled drawings and systems to ensure product complies to those controlled drawings

Service facilities, other than manufacturer's service facilities, will not have any product drawing to ensure compliance of repaired product

Service facilities rely on competent persons to diligently overhaul and repair Ex Equipment using facility process and equipment, within their scope of competence, and as required by IEC 60079-19 and the Type of Protection standard

IECEx SPC 03-5 Service Facility Assessment

During initial service facility assessment their management systems and processes have to be verified for compliance with the IECEx 03 Scheme requirement

That initial assessment must also include a review of the facility workshops, including condition of personnel, workstations, process equipment, measuring instruments, test facilities, material and spare parts storage to assess the capability of the service facility to deliver the services in compliance with the requirements of IEC 60079-19

Subsequent assessments must prioritise assessment of service facility performance by vertical auditing of product together with review of internal and any 3rd party audits

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

This an audit which starts with the random selection of Ex Equipment job files which are reviewed, witnessed and verified together with the responsible person. Preferably one of the job files will be in the work in progress of the service facility

These job files are used to verify that the service facility is complying with the requirements of IEC 60079-19, and the Type of Protection standard, the sample evidence to be witnessed and verified will include but not limited to:

- Record of initial inspection with full nameplate and certification data together with data to verify compliance, or variance from compliance, of Ex Equipment to it's Type of Protection standard, or manufacturers information
- Person conducting the initial inspection has to be competent and the results have to be reviewed by the responsible person

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Audit

- Record of initial inspection with full nameplate and certification data together with data to verify compliance of variance from compliance of Ex Equipment to it's Type of Protection standard, or manufacturers information
- Person conducting any inspection or measurement has to be identified, verified as competent and the results have to be reviewed by the responsible person
- The measuring instruments used to verify compliance mut be identified on the job record and sample instruments checked for condition and validity of calibration
- Where there is variance between the user's initial instruction and the result of the initial inspection there has to be evidence of agreement form the user to the change in the scope of the overhaul and repair

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

- verify that the responsible person has revied and agreed the repair processes and any reclamation processes. Check for evidence that the responsible person is being intimidated by site management
- Review records of any reclamation process undertaken, including rewind, and verify process control procedures has been followed and recorded. Has this been reviewed and approved by the responsible person
- Verify that any process equipment used during any reclamation including rewind is operated and operates as required by the process, particular attention to:
  - burnout ovens temperature control, high temperature suppression & core temperature records
  - curing oven temperature control
  - condition of the impregnation process including the condition of the varnish or resin used and records of any regular verification of the e resin or varnish viscosity & chemistry

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

- Any measurement instruments use must be identified and sample instruments checked for condition and validity of calibration The user must be identified and verified as competent
- Are there records of any parts replaced and where necessary is there an Attestation of Conformity, assess the spare part storage condition in particular for insulation, insulated conductors, bearings and grease
- Verify the inspection during assembly has data used to verify compliance of the overhauled or repaired Ex Equipment to it’s Type of Protection standard, or manufacturers information
- The measuring instruments used to verify compliance mut be identified and sample instruments checked for condition and validity of calibration and used by competent persons

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

- Verify records are legible and signed and dated by persons making the record
- Verify that the User Job Record contains the information as required by IEC 60079-19 including records of:
  - full nameplate and certification data
  - condition as received and results of initial inspection including measurements
  - any parts reclaimed including rewind
  - any parts replaced
  - condition at completion of overhaul or repair including measurements
  - affirmation the status of the Ex Equipment after overhaul and repair
  - signature of the responsible person
  - date
- Verify responsible person has control of issue of Ex Repair labels

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

- Verify condition of overhauled and repaired Ex Equipment surface finish, manufacturer's label & repair label retention together with method and equipment protection used for transport to the user
- Verify the responsible person participates in reviews of the service facility quality management system and has verified that the QMS is effective in meeting the requirements of IEC 60079-19 and the IECEx 03-5 Scheme requirements
- Verify service facility controls for Ex Equipment when the responsible person is on holiday leave, sick or leaves the service facility

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

Using this methodology as auditors you are able to assess the service facility's compliance with the requirements of IEC 60079-19 and other relevant standards and verify that:

- There is an agreement with the User on the status of the equipment after overhaul or repair
- Persons working on the Ex Equipment are competent or working under the control of a competent person
- The measuring instruments are identified, calibrated and used by competent persons with results documented and legible
- The measuring instruments are appropriate for the size of the machine and the degree of accuracy required for the Ex Equipment
- The responsible person reviews the initial inspection results and approves the overhaul or repair procedures and has agreed any change in scope with the User
- The overhaul, and repairs are conducted following documented procedures by competent persons

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

- The responsible person approves any reclamation procedures carried out by competent persons and approved the reclamation records and the result of the reclamation procedure
- The processes used during stator rewinds, burnout, stripping, cleaning, winding, impregnating and curing can all be verified as being effective and under control
- Any spare parts are appropriate and controlled to ensure compliance with IEC 60079-19 and included in the User report
- Insulating materials, winging wire bearings and grease stored and installed appropriately
- The results of final inspection during assembly are approved by the responsible person
- The users report compliant with IEC 60079-19 is signed by the responsible person when there is evidence of compliance of the Ex Equipment to the status as agreed with the user before a repair plate is fitted to the equipment
- The surface finish (paint) and protection and packaging for return to User appropriate

IECEx SFC 03-5 Service Facility Assessment

Service Facility Vertical Auditing

It may not be possible to witness and verify in detail all parts of the process identified during the vertical audit of the job record, this may require assessment of different processes or parts of the processes during subsequent audits.

Previous audit results and what you see can lead you to issues which require further detailed evaluation

Where rotating electric machines are being overhauled and repaired, particular attention needs to be verification of compliance with the requirements of IEC 60034-23. This standard covers the requirements for overhaul and repair of rotating electric machines as industrial equipment which are included as a requirement in IEC 60079-19

IECEx SFC 03-5 Service Facility Assessment

The following slides provide background information for assessors of IECEx SFC 03-5 service facilities

IECEx SFC 03-5 Service Facility Assessment

- Service Facilities operating within the IECEx SFC 03-5 Scheme have to be able to demonstrate their capability of operating to IEC 60079-19
- The most common Ex Equipment overhauled and repaired to IEC 60079-19 are, by far, rotating electric machines, followed by a much smaller number of transformers and control equipment
- From the 2015 amendment to the IEC 60079-19 3rd Edition it was clarified that to maintain Ex Equipment Temperature Classification the efficiency of rotating electric machines has to be maintained following a rewind, guidance was provided via the EASA/AEMT Rewind Study Good Practice Guidance
- This requirement applies to all rotating machines irrespective of the specific Type of Protection

IECEx SFC 03-5 Service Facility Assessment

- In the 4th Edition of IEC 60079-19 it was clarified that for all rotating electric machines the requirements in IEC 60079-19 were in addition to the requirements of IEC 60034-23, the overhaul and repair standard for industrial rotating machines
- With Flameproof Ex “d” equipment there are specific requirements to ensure that the flameproof enclosure is safe which include measurement and verification of flamepath gaps and verification of flameproof enclosure fasteners and threaded holes This must only be conducted by competent persons using calibrated instruments and correctly documented, recorded and reviewed
- Annex C assessment has to be used when assessing any Ex “d” equipment

IECEx SFC 03-5 Service Facility Assessment

- For Ex “e” and Ex “nA” there specific requirements relating to the windings of rotating electric machines, which have been amended many times. As a result it is critical to know the edition of the standard to which the equipment was certified before rewinding, to be aware of specific winding restrictions and test requirements.
- In 2006 IEC60079-7 introduced requirements for stator winding incendivity tests this has to be addressed by the service facility for machines certified to this standard and subsequent editions, by using a manufacturer’s certified winding, certification of the service facility insulation system or testing of rewound stator windings
- The 4th Edition of IEC 60079-19 introduce clarification of requirements for Ex “p” pressurisation and pressurisation systems, verification of how these are being applied is required
- Having a QMS that meets the requirements of IEC 60079-19 and the ExSFC Operating Documents is only the first step in the audit process

IECEx SFC 03-5 Service Facility Assessment

- Service Facilities operate differently to manufacturers (OEM) and do not have the same type of control of production. In an OEM, product will only be used if it meets specific requirements in drawings or tests
- In a Service Facility there will usually be no drawings of the Ex Equipment and any overhauls or repairs will be controlled by competent Operatives and the Responsible Person, supported by the QMS system
- The competence of these people is fundamental to the control of Ex Equipment overhaul and repair and ensuring it is safe to return to service when that work is completed
- The competence and authority of the Responsible Person (RP) within the service facility management has to be assessed and verified. Any change of the RP has to be reviewed and approved by the IECEx CB

IECEx SFC 03-5 Service Facility Assessment

- The only person authorised to permit Ex Equipment to be returned to the user, after overhaul or repair, is the RP. Ex Equipment must only be released for return to the User when the RP has sufficient evidence to verify that the Ex Equipment complies with certification status as agreed with the user.
- If there is only one RP at a facility, procedures must be in place to prevent any authorisation of Ex Equipment repair, reclamation, release or dispatch until the RP is back on site.
- If there are multiple RP's, i.e. in larger facilities, one must be identified as the primary RP and the other RP's work under his control. When the primary RP is off site a deputy RP can be nominated

IECEx SFC 03-5 Service Facility Assessment

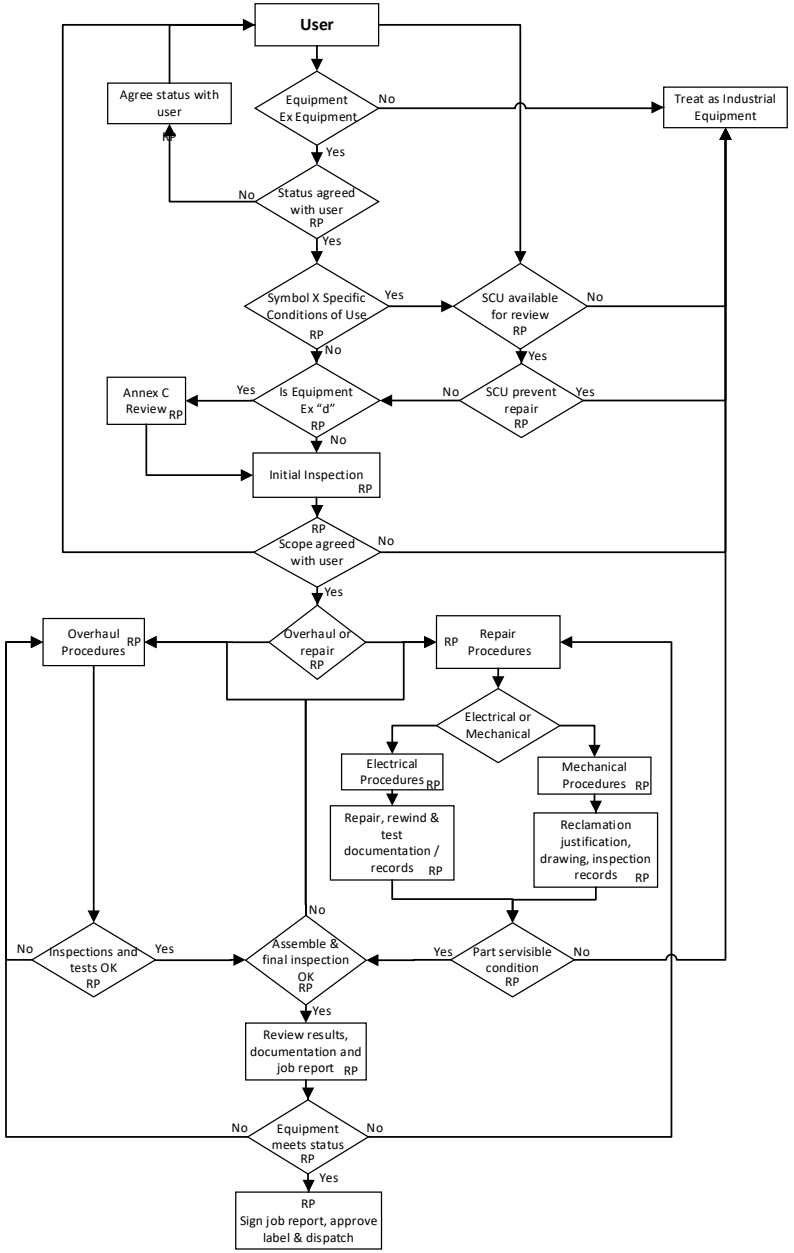
- An IECEx audit has to include verification of compliance to IEC 60079-19 on the shop floor, not just in an office
- Sample Ex Job Records should be reviewed to verify only competent persons or persons under the direct supervision of competent persons worked on the job, that the job records are appropriate for the scope of work and all measurements and testing required are satisfactory
- For Ex “d” equipment condition assessment there must be evidence that the requirements of Annex C of IECEx 60079-19 has been followed and the decisions recorded

IECEx SFC 03-5 Service Facility Assessment

- The RP has to control the overhaul and repair of Ex Equipment, agrees with the user the certification status of the Equipment after repair, agrees the scope of work with the user and approves the repair and reclamation processes, reviews and controls operatives conducting this work, reviews and accept job records to verify compliance with the required certification status
- For an IECEx Service Facility, the competence of the Responsible Person is equally as important as the competence of persons working in an IECEx Test Laboratory within the IECEx 02 Scheme,
- The following service facility operation flow chart indicates where the responsible person (rp) is required to be involved in the process

IECEx SFC 03-5 Service Facility Assessment

Overhaul, repair & reclamation flow chart



IECEx SFC 03-5 Service Facility Assessment

- Equally important is the competence of the service facility to overhaul and repair equipment to perform as it's industrial equipment requirements in addition to complying with Ex requirements
- From end of 2021 all IECEx SFC 03-5 Service Facilities have to operate to the requirements of the 4th Edition of IEC 60079-19 where for rotating electric machines there is now a specific requirement that IEC 60034-23 has to be complied with
- This is the standard which ensures the overhauled and repaired rotating electric machines operates satisfactorily as an item of industrial plant, irrespective of the fact that it is used within a hazardous area

IECEx SFC 03-5 Service Facility Assessment

- One method of verifying a service facilities compliance with IEC 60034-23, is that they have 3rd party assessment such as the EASA Accreditation Program which assesses service facility compliance to EASA Std. AR 100-2020, or any other equivalent
- Although the EASA Accreditation is to EASA Std: AR 100 there is no significant difference to the fundamental requirements of IEC 60034-23
- If the service facility does not have 3rd party accreditation the IECEx CB Audit will have to include this during their audits
- The EASA Accreditation Check List, which a simplified version is below, is an example of what is required during such an assessment, and this requires additional competence for assessors
- Each item in this check list has a separate guidance for assessors on what specifically to look for as evidence of compliance

IECEx SFC 03-5 Service Facility Assessment

IEC 60034-23 Assessment Criteria

Housekeeping	Training
Ex Competence	Internal Audits
Identification & condition assessment	Terminals, leads, connectors & boxes
Cooling system	Shafts
Bearings (rolling element sleeve)	Lubrication
Stator case & bearing housings	Squirrel cage or other rotors
Balancing	Accessories
Winding removal & core condition	Rewind data
Insulation system, conductor & coils	Winding impregnation
Winding tests IR, Ω, surge	Voltage withstand test
Bearing insulation	No-load tests
Finish & handling	Calibration

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

	Score	Checklist item
Criteria		Core testing is performed before burnout or other equivalent process, and after winding removal, and the results are documented. Evaluation assessment of core acceptability (watts per kg and temperature rise) is documented.
		Burnout oven has part temperature limited to 370°C or less, analog or digital recorder; and water mist system is functional.
		test losses increase more than 10% between the before and after winding removal tests, the core is repaired or replaced.
		If core has hot spots with temperature 10^0 K above average core temperature at the end of the core test the core is repaired or replaced
		Parts are oriented and supported in oven so as to avoid distortion.
		Check is performed that core slots are clean and free of sharp edges or particles.
		Core laminations are not loose and teeth are not splayed (i.e., flared at ends of slots).
Equipment	Ø	Confirm calibration and functionality of associated equipment.
		Temperature mete.r
		Water spray, mist or other system (functionality)
		Analog/digital recorder.
		Core tester (wattmeter, ammeter and voltmeter integral with tester).
	Ø	or loop test with separate/standalone Wattmeter, Ammeter, Voltmeter.
Source references: IEC 60034-23 8.2, 8.3.1		

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Audit criteria explanation

Criterion: Core testing is performed before burnout or other equivalent process, and after winding removal, and the results are documented. Evaluation assessment of core acceptability (watts per kg and temperature rise) is documented.

Explanation: The criteria in this clause apply to motors with windings that are to be replaced. Core testing of stators with windings that do not need to be rewound can be performed; however, that is not a requirement of this program.

Core testing can be performed by means of a commercial core tester or the loop test method. A core test is to be performed before the winding removal process and after completion of the burnout or winding removal process. Information that needs to be documented includes the amperes and turns of the test loop (1 turn if commercial core tester is used), the induced voltage (which is directly proportional to the magnetic flux in the core under test), the magnetic flux level, the watts loss per pound/kilogram of core back iron weight, and the core temperature rise.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

The before and after winding removal core test results and assessments (acceptable or unacceptable) are to be documented in the repair record. The magnetic flux level for the after winding removal test should be within 5% of the before winding removal level. The wattmeter, ammeter and voltmeter of a commercial core tester are to have current calibration labels; and the wattmeter(s), ammeter(s) and voltmeter(s) used for any loop tests also are to have current calibration labels. The oven part temperature meter is to have a current calibration label. The analog or digital temperature recorder also is to have a current calibration label. If the oven part temperature sensor is integral with the recorder, only the recorder must have a current calibration label.

Corrective action should be documented in the repair records for stators with after winding removal test values that exceed the acceptable watts/kg or temperature rise limits. The results of the acceptable core test following corrective action are to be documented.

Note: See Reference Information at the end of this checklist clause explanation for additional information about core testing.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Criterion: Burnout oven has part temperature limited to 370°C or less, analog or digital recorder; and water spray, mist or other temperature suppression system is functional.

Explanation: Typically the oven part temperature thermocouple attaches to the stator core. Temperature sensing and recording of the part temperature is required. Although it is preferred that direct (contact) part temperature sensing be used to control part temperature, oven air temperature sensing is acceptable provided part temperatures remain within the prescribed limits. If multiple parts are processed, sensing and recording temperature of each part is required. The reason is that without temperature sensing and recording the actual temperature of any given part(s) would be unknown and may attain a higher temperature outside of prescribed limits.

The temperature suppression system is usually activated by the oven temperature controller. The system can be function tested with the oven at room temperature to confirm that water or other sprays from it by momentarily manually activating and observing the water spray or sensing inert gas. The temperature recordings should be archived after each oven operating cycle to provide evidence that the temperature recorder is functional. The stator(s) processed during each cycle should be marked on the applicable recording, or there should be a log that correlates the recordings to the stators processed.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Criterion: If core test losses increase more than 10% between the before and after winding removal tests, the core is repaired or replaced.

Explanation: The watts/kg values from the before and after winding removal core tests for a stator are to be compared and evaluated. If the “after” value divided by the “before” value is greater than 1.10 (+10%), the core should be repaired or replaced. The corrective action taken when the value exceeds 10% should be documented in the repair records. If the core is repaired the final core test value is to be documented in the repair records. It is suggested that the auditor check at least one active or historical repair before and after core test assessment to verify that the ratio was correctly calculated and interpreted.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Criterion: If there are hot spots with temperature 100 K or greater above the average core temperature at the end of the core flux test, after winding has been removed, the core is repaired or replaced.

Explanation: The evaluation of hot spots and their potential deleterious effect on performance is subjective and based on experiential knowledge. Hot spots result in localized higher operating temperatures on the slot wall and will accelerate ground wall and turn to turn insulation thermal degradation which may result in turn to turn or ground fault. Although repair records need not indicate that this condition existed or was repaired, inspection of active stator rewind work in process should not indicate any hot spots. Note that inactive rewind repairs such as those awaiting customer authorizations to proceed and those in the rewind queue are outside the scope of this inspection. Corrective action taken to address hot spots and successful core test result is to be documented.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Criterion: Parts are oriented and supported in oven so as to avoid distortion.

Explanation: This good practice reduces the possibility of any frame distortion or collateral damage to other stators when multiple stators are processed in the same burnout oven cycle. The feet of the stator should be flat on the oven rack or other support structure. Keeping the feet on the same plane avoids stresses in the frame that could result in distortion. Arranging stators such that core bores do not axially align avoids the tendency of creating a “chimney” effect, which could increase the temperature of the air moving through the stators.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Criterion: Check is performed that core slots are clean and free of sharp edges or particles.

Explanation: Core slots that are not clean can reduce slot space available for the winding, and reduce heat transfer from winding to core. The slots should not have visual evidence of any foreign material. Sharp edges can abrade the conductor insulation, which could cause an electrical short. Similarly, small particles could also abrade conductor insulation; and large and sharp particles could puncture coil to ground insulation such as slot cells. Corrective action taken to address core slots that are not clean and free of sharp edges or particles is to be documented.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Criterion: Core laminations are not loose and teeth are not splayed (i.e., flared at ends of slots).

Explanation: This is a requirement because loose laminations can vibrate and erode ground wall insulation, increase core losses or fracture and enter the airgap. The evaluation of splayed teeth and their potential deleterious effect on performance is subjective and based on experiential knowledge. Core lamination teeth that are splayed (flared out) at the ends of the core will increase the motor stray load losses and vibrate. If that condition is found, the teeth should be tamped and bonded back in place. Although repair records need not indicate that this condition existed or was repaired, inspection of active stator rewind work in process should not indicate any flared laminations. Note that inactive rewind repairs such as those awaiting customer authorizations to proceed and those in the rewind queue are outside the scope of this inspection. Corrective action taken to address loose laminations or splayed teeth is to be documented.

IECEx SFC 03-5 Service Facility Assessment

Example - Winding removal and core integrity

Reference information

Assessing a stator core integrity and condition is done by a core test. The core test can be performed with a commercial core tester or by using the loop test method. This reference information provides background about the core test and methods of performing it.

The commercial core tester is a standalone machine that applies a high current to a single turn wrapped around a stator core. The loop test method utilizes multiple turns wrapped around the core so as to obtain the required magnetization. The principle of the magnetization is that magnetic strength is a function of amperes multiplied by turns. Thus for a specific core the commercial core tester would use many amperes and one turn, and the loop test would use many turns at a much lower current (ampere) level.

The ampere-turn value of a core test is reference information and is not used for core evaluation. The typical magnetic flux level of the test is 1.5 Tesla for 50 Hz machines and 1.32 Tesla for 60 Hz machines. The induced voltage level that is equivalent to this flux density value is calculated as part of the test routine. The watts/ kg limit for a satisfactory core depends upon the size and design of the machine and ranges from 4.0 - 10 watts/kg). The core temperature rise is the difference between the highest core temperature at the end of the test period minus the initial core temperature, which should be equal to the room (ambient) temperature. The typical limit for core temperature hot spot rise is 10°C above the average core temperature at the end of the test.

IECEx SFC 03-5 Service Facility Assessment

- This example was of a accreditation program operated by EASA Inc, and as such is their copyright and intellectual property
- EASA have been given permission for its use in this presentation to provide IECEx assessors guidance on the depth of assessment required to verify a service facilities capability of providing the level of service required by overhaul and repair or rotating electric machine users
- Details of the EASA Accreditation Program are available at www.easa.com
- The EASA Accreditation Check List includes an equipment check list which goes a long way to meeting equipment required by an IECEx Service Facility, however one obvious omission is calibrated GO, NO-GO thread gauges

IECEx 03-5 Service Facility Assessment

EQUIPMENT

- Unless notified otherwise, all equipment listed must be on site and functional
- Except for gauge blocks, all instruments must be calibrated at least annually to applicable national standards. After initial accreditation is achieved, the service centre must retain calibration records for a 3-year period, or until the next external audit is performed
- Verification: Conforming, through the use of objective evidence, that specified requirements have been fulfilled

Notes: -

[1] Must have either one or both of these items

[2] Outsourcing permissible

[3] Periodic verification by gauge block manufacturer or other qualified external source

[4] Only applies if service centre has VPI system (VPI outsourcing permissible)

IECEx 03-5 Service Facility Assessment

Electrical

Milli-ohmmeter
Ohmmeter
Voltmeter (AC)
Ammeter (AC)
Wattmeter (AC)
Megohmmeter
High-potential tester
Surge tester
Core tester [1]
Loop test [1]
Growler (functional)
Test panel (to motor rated voltage; individual instruments calibrated)

IECEx 03-5 Service Facility Assessment

MECHANICAL

Inside micrometers

Outside micrometers

GO, NO_GO gauges

Dial Indicators (verification by service centre)

Digital tachometer (verification by service centre)

Terminal crimpers (verification by service centre)

Vibration meter

Balancing machine[2]

Gauge blocks (if applicable) [3]

IECEx 03-5 Service Facility Assessment

Physical

Temperature meters

Burnout oven part temperature controlled

Burnout oven analog or digital recorder

Burnout oven water mist or spray, or inert gas temperature supression system (verification by service centre)

Bake oven temperature control

Winding machine with turns counter (verification by service centre)

VPI system vacuum gauge [4]

VPI system pressure gauge [4]

Thank you for your time

QUESTIONS?

If you think of any later contact me at
john.allen@sheppardeng.co.uk