

*Standards and
Assessment Guide*

**REFRIGERATION
AND AIR
CONDITIONING**

Introduction

Welcome to the Standards and Assessment Guide (SAG), a comprehensive resource designed to support excellence in assessment practices for all skills competitions hosted at the WorldSkills Competition. A key component of the SAG is the commitment to continuous improvement through ongoing review, ensuring that these guides consistently reflect the latest industry innovations and high standards of assessment in an open and transparent manner.

Purpose

The primary purpose of this guide is to provide a structured framework for the consistent and fair assessment of each skill competition. It aims to ensure that all assessments are conducted with a high degree of accuracy, reliability, validity, and reflect global industry standards. By adhering to these guidelines, assessors can maintain the integrity of the competition and uphold the high standards associated with WorldSkills.

Note: this guide is not a replacement for the Marking Scheme and should only be used as a reference when required during the assessment process. Competitors are **not** allowed to have a copy of this SAG in the workshop in either digital or paper form.

Scope

This document covers general assessment practices applicable to a diverse range of industry sectors including:

- Manufacturing and Engineering Technology
- Information and Communication Technology
- Construction and Building Technology
- Transportation and Logistics
- Social and Personal Services
- Creative Arts and Fashion

Each skill competition has its unique requirements and benchmarks, which are detailed within sections of this guide. The consistency of assessment across each skill is the overarching principle, ensuring a unified approach to evaluating Competitor performance to the highest standards.

Key Components

The guide is structured into several key components, each addressing critical aspects of the assessment process:

Assessment Principles and Objectives

- Emphasis on fairness, transparency, and objectivity in assessments.
- Alignment with global industry standards and best practices.

Assessment Methods and Tools

- Description of various assessment methods in Measurement and Judgement.
- Guidance on the application of appropriate assessment tools and equipment (if applicable).

Criteria and Benchmarks

- Examples of assessment criteria and aspects for each skill, outlining the expected competencies and performance standards.
- Benchmarks for different levels of proficiency i.e. Judgement award range 0, 1, 2, 3 or Yes/No criteria alongside clear measurable descriptors.

Expert assessment requirements

- Completion of the Access Programme.
- Approved Curriculum Vitae (CV).
- Reaching **100%** Expert preparedness.
- Full participation of online and in-person Mandatory Assessment Training (MAT).
- Completion of practical assessment testing at the Competition.

Quality Assurance and Improvement

- Monitoring and evaluation: Ensuring assessments are carried out correctly and produce reliable results.
- Continuous improvement: Using feedback from Experts and Skill Competition Managers to enhance future assessments.
- Periodic review: Regularly updating processes to reflect current industry and WorldSkills standards.

Implementation

For effective implementation, this guide should be used for guidance purposes only and in parallel with the Technical Description for each skill. Experts are encouraged to familiarize themselves thoroughly with both the general guidelines and the particular requirements of their respective skill areas. Collaborative efforts between the Skill Management Team, Experts, and Competitors are vital for achieving the ultimate goal of global skills development.

Conclusion

The Standards and Assessment Guide embodies the commitment of the WorldSkills movement to nurturing talent and promoting the highest standards of vocational education and training worldwide. By providing clear and comprehensive guidance, we aim to empower Experts to conduct marking and assessment practices that are not only rigorous and equitable but also inspiring and transformative for all participants.

Thank you for your dedication to upholding these standards and contributing to the success of the WorldSkills Competition. Together, we can continue to champion skills excellence and celebrate the achievements of talented individuals from around the globe.

Skill 38 – Refrigeration and Air Conditioning

This document provides the standards for the assessment Aspects, which are identified as either Measurement or Judgement

Measurement (M)

Measurement is used to assess accuracy, precision, and other performance that can be measured objectively. It is used where ambiguity must be avoided.

The total marks allocated to measurement marking may vary from competition to competition depending on the Test Project.

The assessment group comprises three Experts plus one Expert. It is forbidden for Experts to assess their own compatriot Competitor.

Judgement (J)

Judgement is used to assess the quality of performance about which there may be small differences of view when applying the external benchmarks.

The Resources column in the table below may include all kinds/formats of resources such as: a link to a YouTube video, a website link, an illustration, a photo, a reference to a book, and so on. It needs to be as detailed as possible to show the differentiation between 0, 1, 2, 3.

Generic rules:

The assessment group comprises three Experts plus one Expert who acts as the supervisor. The supervising Expert will replace an Expert in the marking group to prevent compatriot marking.

The difference of the three Experts' scores may not exceed 1. If this is the situation the Experts must re-score until there is a maximum difference of 1. As long as the three Experts judge within 1, the result can be entered into the CIS.

The total marks allocated to judgement marking may vary from competition to competition depending on the Test Project.

WorldSkills Occupational Standards (WSOS) sections per the Technical Description:

- Work organization and management
- Communication and interpersonal skills
- Design refrigeration and air conditioning systems
- Installation and maintenance of refrigeration and air conditioning
- Commission refrigeration and air conditioning systems
- Fault finding refrigeration and air conditioning systems

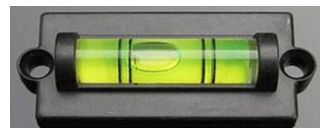
Standards and Assessment Guide Sections

- Copper Pipe Work
- Major Component Installation
- Refrigerant Flow Control Installation
- Electrical Cable Installation
- Electrical Testing and Fault Finding
- Pressure Testing
- Evacuation
- Refrigerant Charging
- Commissioning and Fault Finding
- Refrigerant Recovery
- Work Practices and Safety

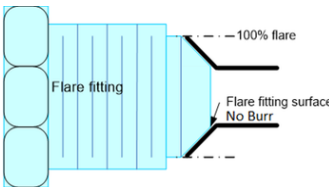
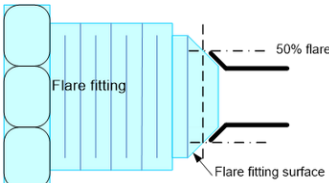
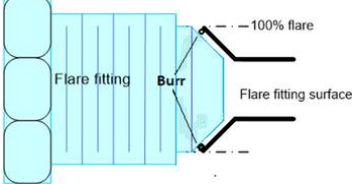
COPPER PIPE WORK

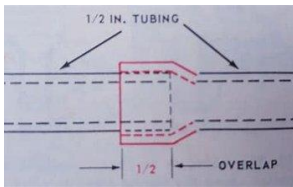
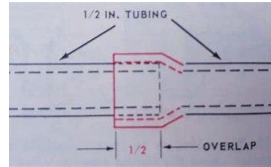
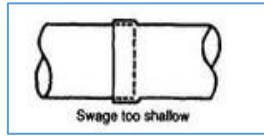
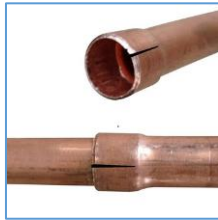
ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.1 Pipe straightness	J	4	3	Performance wholly exceeds industry best practice and is judged as excellent: Tube is perfectly straight +/- 0 mm over 400 mm when put against a straight edge		400 mm Straight edge or angle 2 and 4 mm feeler gauge
			2	Performance meets industry criterion and surpasses that standard to some extent: Tube is straight +/- 2 mm over 400 mm when put against a straight edge		
			1	Performance meets industry benchmark: Tube is straight +/- 4 mm over 400 mm when put against a straight edge		
			0	Performance below norm standards: Tube is not straight, greater than 4 mm deflection over 400 mm when put against a straight edge		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.2 Vertical and horizontal pipe work – except horizontal suction lines	J	4	3	Performance wholly exceeds industry best practice and is judged as excellent: spirit level bubble is at the centre		Spirit level
			2	Performance meets industry criterion and surpasses that standard to some extent: spirit level bubble is within the inner lines but towards one end		
			1	Performance meets industry benchmark: spirit level bubble is within the outer lines or touching the line		
			0	Performance below industry norm: spirit level bubble is not within the lines		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.3 Horizontal suction line pipe work	J	4	3	Performance wholly exceeds industry best practice and is judged as excellent: • pipework slopes 2 mm in 400 mm (1:200) pitch (+/-1 mm) towards the compressor to allow for oil return, and • spirit level bubble is within the inner lines and slopes down toward compressor		• Spirit level • 2 mm feeler gauge
			2	Performance meets industry criterion and surpasses that standard to some extent: • pipework slopes 2 mm in 400 mm (1:200) pitch (+/-1 mm) towards the compressor to allow for oil return, and • spirit level bubble is within the outer lines		
			1	Performance meets industry benchmark: • pipework does not slope 2 mm in 400 mm (1:200) pitch (+/-1 mm) towards the compressor to allow for oil return, and • spirit level bubble is at the centre, that is no slope at all.		
			0	Performance below industry norm: • pipework does not slope or exceeds 2 mm in 400 mm (1:200) pitch (+/-1 mm) towards the compressor to allow for oil return or slopes away from compressor, or • spirit level bubble is not within the lines		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.4 All pipe right angle bends	J	4	3	Performance wholly exceeds industry best practice and is judged as excellent: No kinks, grooves or scratches on pipe, (the correct bender for the tube diameter, with no evidence of kinking, flattening, cracking, or distortion) correct bend angle ($90^\circ \pm 2^\circ$), diameter of the pipe is full and correct, and bend radius is less than 10 times the diameter of pipe.		- Digital Sliding T-Bevel Gauge and Protractor - Samples
			2	Performance meets industry criterion and surpasses that standard to some extent: minor small kinks, grooves or scratches on pipe, but defects will not affect operation, correct angle ($90^\circ \pm 5^\circ$), correct diameter of the pipe, one blemish (marks caused by the bender's correct use are acceptable), and bend radius is less than 10 times the diameter of pipe.		
			1	Performance meets industry standards: small kinks, grooves or scratches on pipe, correct bend angle ($90^\circ \pm 5^\circ$), slightly reduced diameter of the pipe, two blemishes (marks caused by the bender's correct use are acceptable), and bend radius is less than 10 times the diameter of pipe.		

			0	Performance below industry norm: • large kinks, grooves or scratches on pipe, • bend angle not correct ($90^\circ \pm 5^\circ$), • diameter of the pipe reduced, • more than three blemishes (<i>marks caused by the bender's correct use not included</i>), or • bend radius is more than 10 times the diameter of pipe.	 	
1.5 Pipe flares	M	4	Yes	Performance meets industry benchmark: • flare is no more than 100% and no less than 75% of the flare fitting surface, and therefore, • Fits into hole in Go/No Go metal block, but does not slip through it, and • Has no burr or split on flare face	 	• Go/No Go metal block template  • Samples
			No	Performance below industry norm: • flare is more than 100% or less than 75% of the flare fitting surface, and therefore, • Does NOT fit into hole in Go/No Go metal block or slips through it, or • Has a burr or split on flare face	 	

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.6 Pipe swages	M	4	3	Performance wholly exceeds industry best practice and is judged as excellent: no splits in the tube, - swage length at least the same as the tube diameter, and - inside circumference is smooth/circular, without swage head marks	 	- Ruler - Feeler gauge - Samples
			2	Performance meets industry criterion and surpasses that standard to some extent: no splits in the tube, - swage length at least the same as the tube diameter, and - inside circumference rough/staggered, from swaging in one action	 	
			1	Performance meets industry benchmark: no splits in the tube, - swage length at least the same as the tube diameter less 2 mm, and - inside circumference rough/staggered, from swaging in one action		
			0	Performance below industry norm: split/s in the tube, - swage length is less than 2 mm of the tube diameter, or - inside circumference rough/staggered, from swaging in one action	 	

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.7 Using the supplied pipe supports/clamps/hangers	J	4	3	Performance wholly exceeds industry best practice and is judged as excellent: • support is securely fastened to the pipework or mounting point, • supports the pipe work and limits the transfer of vibration, • spacing are no more than 400 mm apart, and • where a straight length of pipework is less than 400 mm, but a change in direction or component is installed, there is at least one pipe support located in either of the horizontal or vertical planes, no more than 400 mm apart.		• Tape measure • Ruler
			2	Performance meets industry criterion and surpasses that standard to some extent: • support is securely fastened to the pipework or mounting point, • supports the pipe work and limits the transfer of vibration, • spacing are no more than 500 mm apart, and • where a straight length of pipework is less than 400 mm, but a change in direction or component is installed, there is at least one pipe support located in either of the horizontal or vertical planes, no more than 500 mm apart.		
			1	Performance meets industry benchmark: • support is securely fastened to the pipework or mounting point, • supports the pipe work and limits the transfer of vibration,		

			0	Performance below industry norm: - support is not securely fastened to the pipework or mounting point, - does not support the pipe work or limit the transfer of vibration, fabrication of brackets or supports is from other materials, for example copper tube, or - pipe clamps are positioned over a brazed pipe fitting or in the radius of the bend.		
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ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.8 Pipework clearances	M	4	Yes	Performance meets industry benchmark: there is at least 20 mm clearance between the bare pipework or the outer insulation (insulated pipe) and other components and pipework, except for access penetrations where at least 5 mm clearance is required		- Ruler 20 mm gauge/tem plate /blocks
			No	Performance below industry norm: the clearance between the bare pipework or the outer insulation (insulated pipe) and other components and pipework is less than 20 mm and for access penetrations less than 5 mm.		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.9 Pipe Insulation	J	4	3	Performance wholly exceeds industry best practice and is judged as excellent: - for Refrigeration systems, the suction pipe work is fully covered by the insulation after the pipework has been pressure tested and assessed, - for Heat Pump Systems and the equivalent, both suction and liquid lines between the outdoor and indoor units are fully insulated per manufacturer's recommendations after the pipework has been pressure tested and assessed, - insulation surface is not damaged in any way, - where insulation has been cut and wrapped around pipe work, or where insulation sections joined together, the insulation is sealed using the supplied adhesive - where the pipe supports are fitted over the insulation, the insulation has No visible flattening, splitting, cracking, or deformation, and - the insulation is vapour sealed to the pipe work using appropriate adhesive.	  	
			2	Performance meets industry criterion and surpasses that standard to some extent: - for Refrigeration systems, the suction pipe work is fully covered by the insulation after the pipework has been pressure tested and assessed, - for Heat Pump Systems and the equivalent, both suction and liquid lines between the outdoor and indoor units are fully insulated per manufacturer's recommendations after the pipework has been pressure tested and assessed, - insulation surface compression depth does not exceed 10% of insulation thickness,		

				- where insulation has been cut and wrapped around pipe work, or where insulation sections joined together, the insulation is continuously sealed around the entire perimeter with no visible gaps using the supplied adhesive - where the pipe supports are fitted over the insulation, the insulation has minor visible deformation that does not affect function or dimensions, and - the insulation is vapour sealed to the pipe work using appropriate adhesive.	
			1	Performance meets industry benchmark: - for Refrigeration systems, the suction pipe work is fully covered by the insulation after the pipework has been pressure tested and assessed, - for Heat Pump Systems and the equivalent, both suction and liquid lines between the outdoor and indoor units are fully insulated per manufacturer's recommendations before the pipework has been pressure tested and assessed, - insulation surface compression depth does not exceed 20% of insulation thickness, - where insulation has been cut and wrapped around pipe work, or where insulation sections joined together, the insulation is continuously sealed around the entire perimeter with no visible gaps using the supplied adhesive - where the pipe supports are fitted over the insulation, the insulation has noticeable deformation affecting appearance or dimensional accuracy, and - the insulation is vapour sealed to the pipe work using appropriate adhesive.	

			0	Performance below industry norm: - insulation is not fitted, not sealed or only sealed using electrical PVC or insulation tape, or - insulation is deformed more than 30% of insulation thickness or damaged beyond vapour seal effectiveness.	
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ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
1.10 Copper tube brazed joints Notes: • Copper to copper brazed joints, a filler rod of at least 15% +/- 3% silver content must be used • Copper to brass or steel brazed joints, a filler rod of at least 45% +/- 3% silver content must be used	J	4	3	Performance wholly exceeds industry best practice and is judged as excellent: - joint does not leak under pressure on first pressure test, Dry nitrogen was bled through the pipework during brazing using a low flow regulator, the entry sealed with a fitting or pieced in the end cap or taped, with one end left open, - correct brazing alloy used, Continuous, even brazing ring around the joint circumference, even, smooth with less than 3 mm excess run/blob above the shoulder edge OR 2mm run/blob below the shoulder edge on the pipe, and no metal damage, over-heating, flux residue, or component scorching	 	Samples
			2	Performance meets industry criterion and surpasses that standard to some extent: does not leak under pressure on first pressure test, Dry nitrogen was bled through the pipework during brazing using a low flow regulator, the entry sealed with a fitting or pieced in the end cap or taped, with one end left open, - correct brazing alloy used, Continuous, brazing ring around the joint circumference, uneven, lacking smoothness with more than 4 mm excess run/blob above the shoulder edge OR more than 3mm run/blob below the shoulder edge on the pipe, no metal damage, no flux residue or component scorching, and - no over-heating of alloy.	  	

			1	Performance meets industry benchmark: • does not leak under pressure on first pressure test, • <i>Dry nitrogen was bled through the pipework during brazing using a low flow regulator, the entry sealed with a fitting or pieced in the end cap or taped, with one end left open,</i> • correct brazing alloy used, • Continuous, brazing ring around the joint circumference, uneven, lacking smoothness with more than 6 mm excess run/blob above the should edge OR more than 4mm run/blob below the shoulder edge on the pipe, • no metal damage and no flux residue or component scorching, and • some over-heating of alloy (bubbles)	 	
			0	Performance below industry norm: • joint leaks under pressure, • <i>Dry nitrogen was NOT bled through the pipework during brazing using a low flow regulator, the entry NOT sealed with a fitting or pieced in the end cap or taped, with one end NOT left open,</i> • incorrect sliver solder used, • NO continuous, brazing ring around the joint circumference, significant voids, lack of filler, leakage, or joint failure, with more than 8 mm excess run/blob above the should edge OR more than 8mm run/blob below the shoulder edge on the pipe, • brazing alloy not melted into joint, • metal damaged/burnt, flux residue, or component scorching.	 	

MAJOR COMPONENT INSTALLATION

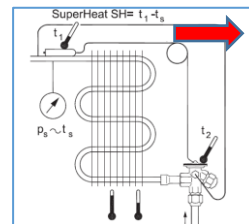
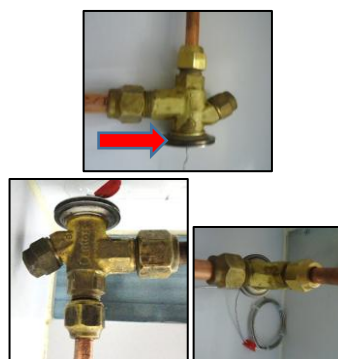
ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
2.1 Compressor location	M	4	Yes	Performance meets industry benchmark: compressor is installed in specified orientation and location +/- 2 mm.		- System diagram - Ruler - Tape measure - Template
			No	Performance below industry norm: compressor is NOT installed in specified orientation or location +/- 2 mm.		
2.2 Compressor mounting	M	4	Yes	Performance meets industry benchmark: - compressor is installed using mounting kit, and - securely fixed at 4 mounting points using correct fixing materials per manufacturer's instructions		Manufacturer's installation instructions
			No	Performance below industry norm: - compressor is NOT installed using mounting kit, or not securely fixed at 4 mounting points using correct fixing materials per manufacturer's instructions		
2.3 Air cooled condenser	M	4	Yes	Performance meets industry benchmark: It is: - installed in specified orientation and location +/- 2 mm, and - securely fixed using correct fixing materials per manufacturer's instructions.		- System diagram - Ruler - Tape measure - Template
			No	Performance below industry norm: It is NOT: - installed in specified orientation or location +/- 2 mm, or - securely fixed using correct fixing materials per manufacturer's instructions.		

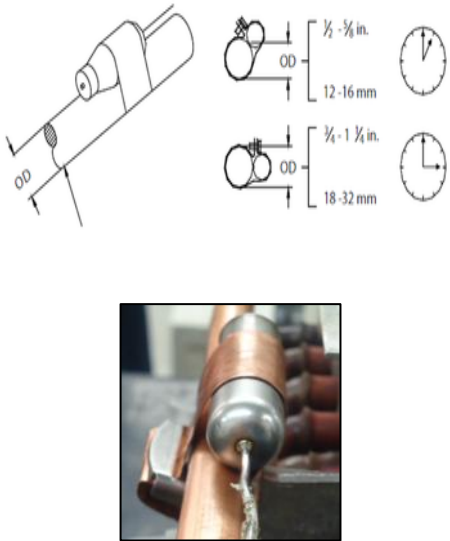
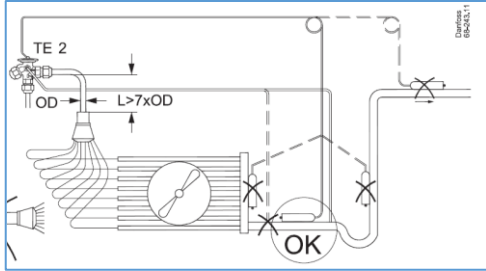
ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
2.4 Bare pipe condenser	M	4	Yes	Performance meets industry benchmark: It is: - installed in specified orientation and location +/- 2 mm, and - securely fixed using correct fixing materials per project instructions.		- System diagram - Ruler - Tape measure - Template
			No	Performance below industry norm: It is NOT: - installed in specified orientation or location +/- 2 mm, or - securely fixed using correct fixing materials per project instructions.		
2.5 Liquid receiver	M	4	Yes	Performance meets industry benchmark: It is: - installed in specified orientation and location +/- 2 mm, and - securely fixed using correct fixing materials per project instructions.		- System diagram - Ruler - Tape measure - Template
			No	Performance below industry norm: It is NOT: - installed in specified orientation or location +/- 2 mm, or - securely fixed using correct fixing materials per project instructions.		
2.6 Fan forced evaporator	M	4	Yes	Performance meets industry benchmark: It is: - installed in specified orientation and location +/- 2 mm, and - securely fixed using correct fixing materials per manufacturer's instructions.		- System diagram - Ruler - Tape measure - Template
			No	Performance below industry norm: It is NOT:		

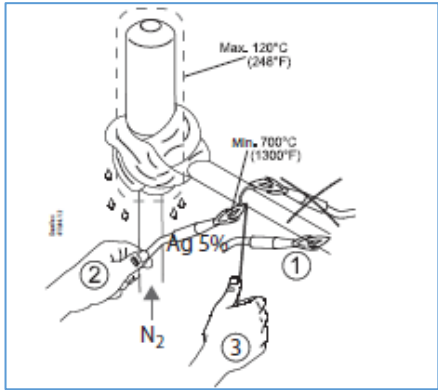
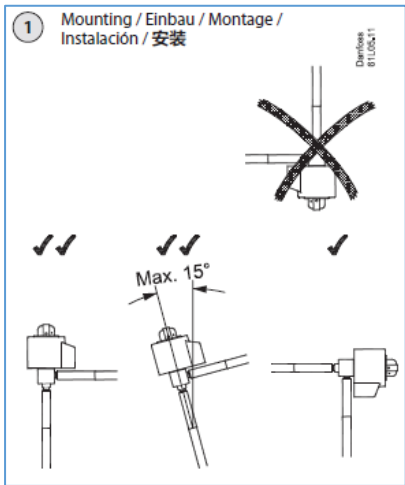
				- installed in specified orientation or location +/- 2 mm, or - securely fixed using correct fixing materials per manufacturer's instructions.		
2.7 Bare pipe evaporator	M	4	Yes	Performance meets industry benchmark: It is: - installed in specified orientation and location +/- 2 mm, and - securely fixed using correct fixing materials per project instructions.		- System diagram - Ruler - Tape measure - Template
			No	Performance below industry norm: It is NOT: - installed in specified orientation or location +/- 2 mm, or - securely fixed using correct fixing materials per project instructions.		
2.8 Suction accumulator	M	4	Yes	Performance meets industry benchmark: It is: - installed in specified orientation and location +/- 2 mm, and - securely fixed using correct fixing materials per project instructions.		- System diagram - Ruler - Tape measure - Template
			No	Performance below industry norm: It is NOT: - installed in specified orientation or location +/- 2 mm, or - securely fixed using correct fixing materials per project instructions.		
2.9 Electrical control box	M	5	Yes	Performance meets industry benchmark: It is: - installed in specified orientation and location +/- 2 mm, - installed level with spirit level bubble at its centre, and - securely fixed using correct fixing materials per project instructions.		- System diagram - Spirit level - Ruler

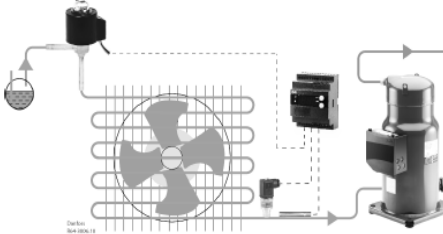
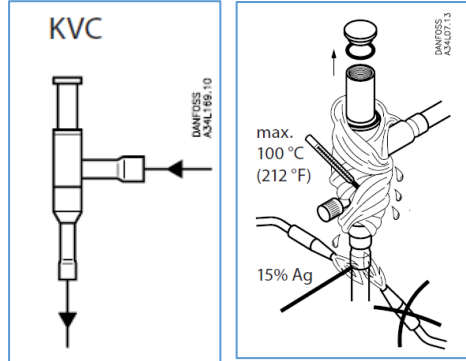
			No	Performance below industry norm: It is NOT: • installed in specified orientation or location +/- 2 mm, • installed level with spirit level bubble at its centre, or • securely fixed using correct fixing materials per project instructions.		• Tape measure • Template
2.10 Pressure control/s	M	4	Yes	Performance meets industry benchmark: It is installed: • in specified orientation and location +/- 2 mm, • to provide access for testing and adjustment, and • securely fixed using correct fixing materials per manufacturer's instructions.		• System diagram • Ruler • Tape measure • Template • Manufacturer's installation instructions
			No	Performance below industry norm: It is NOT installed: • in specified orientation or location +/- 2 mm, • to provide access for testing and adjustment, or • securely fixed using correct fixing materials per manufacturer's instructions.		

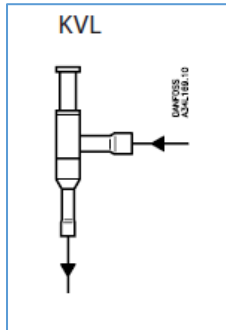
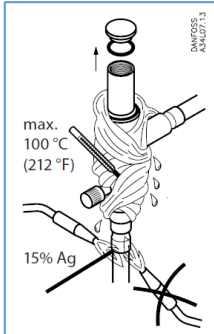
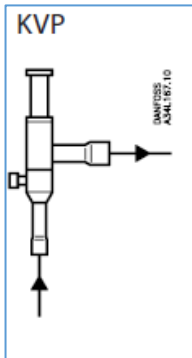
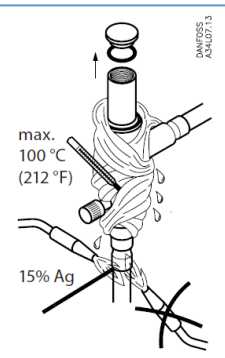
REFRIGERANT FLOW CONTROL INSTALLATION

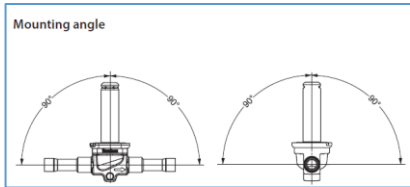
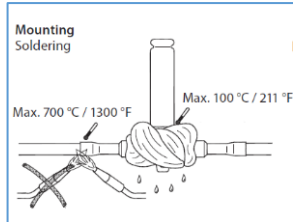
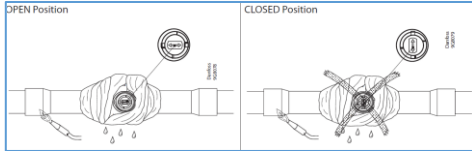
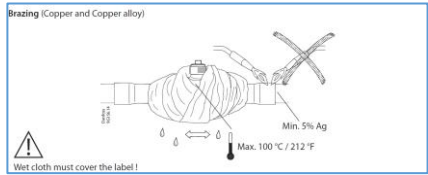
ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
3.1 Thermostatic expansion valve body	M	4	Yes	Performance meets industry benchmark: It is installed • as per manufacturer instructions and: • in the correct location in system, • with the diaphragm information readable • with correct refrigerant flow, and • with the external equaliser line fitted to the outlet of the evaporator after the bulb • with clear access to superheat adjustment stem.		• System diagram • Manufacturers instructions
			No	Performance below industry norm: It is NOT installed • as per manufacturer instructions, or: • in the correct location in system, • with the diaphragm information readable, • with correct refrigerant flow, or • with the external equaliser line fitted to the outlet of the evaporator after the bulb • with clear access to superheat adjustment stem.		

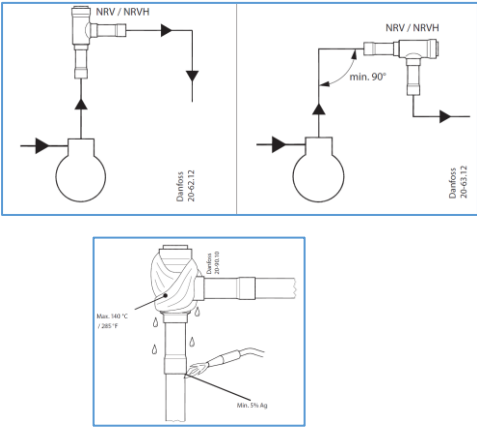
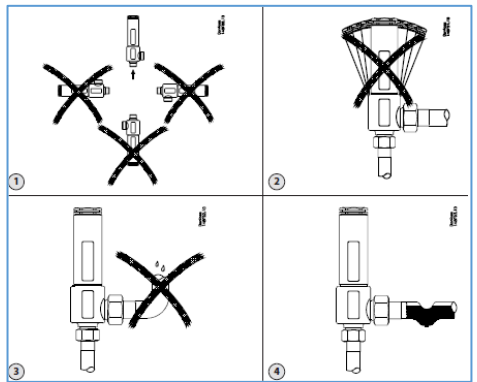
3.2 Thermostatic expansion valve bulb	M	4	Yes	Performance meets industry benchmark. It is installed: • as per manufacturer instructions or: • secured (OEM torque) and in the correct location on system, • before the external equaliser pipe if fitted, • at 1 or 11 o'clock position on 1/2" and 5/8" pipe, • insulated, and • with bulb capillary secure • where capillary line is straightened, it needs to be secure and free from vibration		• System diagram • Manufacturers instructions
			No	Performance below industry norm: It is NOT installed: • as per manufacturer instructions, • secured (OEM torque) and in the correct location on system, • before the external equaliser pipe if fitted, • at 1 or 11 o'clock position on 1/2" and 5/8" pipe, • insulated, and • with bulb capillary not secure • where capillary line is straightened, it needs to be secure and free from vibration		

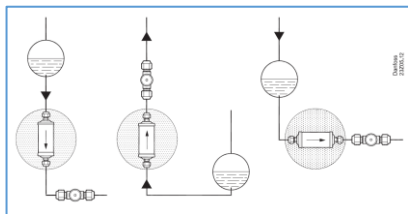
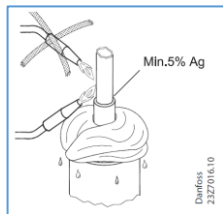
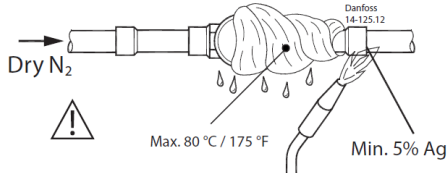
ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
3.3 Electronic expansion valve body	M	4	Yes	Performance meets industry benchmark: It is installed: • per manufacturer instructions and: • in the correct location in system, • positioned in the correct vertical plan angle • with correct refrigerant flow, • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing,	 	• System diagram • Manufacturers instructions
			No	Performance below industry norm: It is NOT installed: • per manufacturer instructions, • in the correct location in system, • with correct flow, • positioned in the correct vertical plan angle • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing		

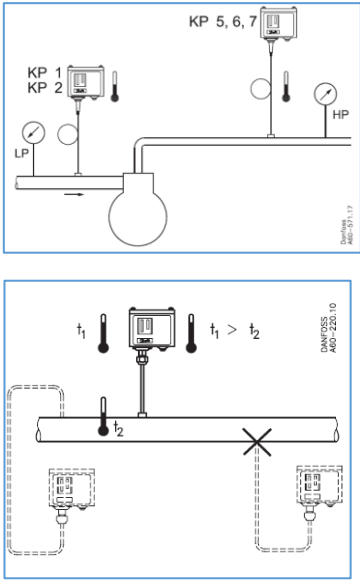
3.4 Electronic expansion valve temperature sensor	M	4	Yes	Performance meets industry benchmark. It is installed: • as per manufacturer instructions and: • securely (OEM torque) in the correct location in system, • at 2 or 10 o'clock position on the pipe, and • insulated		• System diagram • Manufacturers instructions
			No	Performance below industry norm. it is NOT installed: • as per manufacturer instructions, • secured (OEM torque) in the correct location in system, • at 2 or 10 o'clock position on the pipe, or • insulated		
3.5 Hot gas bypass valve	M	4	Yes	Performance meets industry benchmark. It is installed • per manufacturer instructions and: • in the correct location in system, • with correct refrigerant flow, • with access for service and adjustment and • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		• System diagram • Manufacturers instructions
			No	Performance below industry norm. It is NOT: • installed per manufacturer instructions, • in the correct location in system, • with correct flow, • clear access for service and adjustment, • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		

ASPECT	ASPECT	WSOS	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT
3.6 Crankcase pressure regulator	M	4	Yes	Performance meets industry benchmark. It is installed • per manufacturer instructions and: • in the correct location in system, • with correct refrigerant flow, • with access for service and adjustment, • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing • was brazed with correct solder alloy content.	 	• System diagram • Manufacturers instructions
			No	Performance below industry norm. It is NOT installed: • per manufacturer instructions, • in the correct location in system, • with correct flow, • with access for service and adjustment • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		
3.7 Evaporator pressure regulator	M	4	Yes	Performance meets industry benchmark. It is installed: • per manufacturer instructions and: • in the correct location in system, • with correct refrigerant flow, • with access for service and adjustment, • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing, and • was brazed with correct solder alloy content.	 	• System diagram • Manufacturers instructions
			No	Performance below industry norm. it is NOT installed: • per manufacturer instructions, • in the correct location in system, • with correct flow, • with access for service and adjustment, • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
3.8 Solenoid valve	M	4	Yes	Performance meets industry benchmark. It is installed: • as per manufacturer instructions and: • in the correct location in system, • with correct refrigerant flow, • with the correct vertical mounting angle • wrapped in wet cloth before silver brazing • was brazed with correct solder alloy content.	 	• System diagram • Manufacturers instructions
			No	Performance below industry norm. It is NOT installed: • as per manufacturer instructions • in the correct location in system, • with correct flow, • with the correct vertical mounting angle, • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		
3.9 Ball valve	M	4	Yes	Performance meets industry benchmark. It is installed: • per manufacturer instructions and: • in the correct location in system, • with correct refrigerant flow, • clear access for service operation, • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing • was brazed with correct solder alloy content.	 	• System diagram • Manufacturers instructions
			No	Performance below industry norm. it is NOT installed: • per manufacturer instructions, • in the correct location in system, • with correct flow, • with clear access for service operation, • wrapped in wet cloth before silver brazing, or		

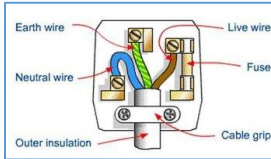
				• with dry nitrogen used during brazing • was brazed with correct solder alloy content.		
3.10 Check valve or non-return valve	M	4	Yes	Performance meets industry benchmark. It is installed: • per manufacturer instructions and: • in the correct location in system, • with correct refrigerant flow, • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		• System diagram • Manufacturers instructions
			No	Performance below industry norm. it is NOT installed: • per manufacturer instructions • in the correct location in system, • with correct flow, • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		
3.11 Pressure relief valve	M	4	Yes	Performance meets industry benchmark. It is installed: • per manufacturer instructions and: • in the correct location in system, • with the correct vertical mounting angle, • with correct refrigerant flow, • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing, and • was brazed with correct solder alloy content.		• System diagram • Manufacturers instructions
			No	Performance below industry norm. it is NOT installed: • per manufacturer instructions, • in the correct location in system, • with correct flow, • with the correct vertical mounting angle, • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		

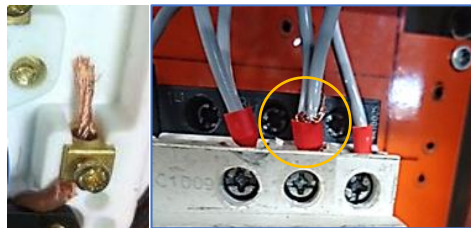
3.12 Liquid line filter dryer	M	4	Yes	Performance meets industry benchmark. It is installed: • per manufacturer instructions and; • in the correct location in the liquid line directly after the receiver and before any solenoid valve, sight glass and the expansion valve, • with correct refrigerant flow, • On a system with a liquid receiver, it can be any orientation (vertical or horizontal), • On a system without a liquid receiver, it must be installed with the outlet lower than its inlet, and • with dry nitrogen used during brazing • was brazed with correct solder alloy content.	  	• System diagram • Manufacturers instructions
			No	Performance below industry norm. it is NOT installed: • per manufacturer instructions, • in the correct orientation or location in system, • with correct flow, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		
3.13 Sight glass	M	4	Yes	Performance meets industry benchmark. It is installed: • per manufacturer instructions and; • in the correct location in the liquid line after the filter dryer and before the expansion valve, • with correct refrigerant flow, • wrapped in wet cloth before silver brazing, and • with dry nitrogen used during brazing • was brazed with correct solder alloy content.	 	• System diagram • Manufacturers instructions
			No	Performance below industry norm: It is NOT installed: • per manufacturer instructions, • in the correct location in system, • with correct flow, • wrapped in wet cloth before silver brazing, or • with dry nitrogen used during brazing • was brazed with correct solder alloy content.		

3.14 Suction line heat exchangers and/or other system accessories.	M	4	Yes	Performance meets industry benchmark. It is installed: - per manufacturer instructions and; - in the correct location immediately following the evaporator, - with liquid and suction lines connected in counter flow, and - with dry nitrogen used during brazing, - was brazed with correct solder alloy content.		- System diagram - Manufacturers instructions
			No	Performance below industry norm. it is NOT installed: - per manufacturer instructions, - in the correct location in system, - with liquid and suction lines connected in counter flow, or - with dry nitrogen used during brazing, - was brazed with correct solder alloy content.		
3.15 Pressure control piping	M	4	Yes	Performance meets industry benchmark: The pressure control is piped: - per manufacturer instructions and; - Per project system diagram, - so that high-pressure safety control cannot be isolated, - so that high-pressure sensing point must be in the primary refrigerant flow circuit, and must always sense discharge pressure, - with access for service and adjustment, - so as not to trap oil in the connecting pipe work, - so that low-pressure sensing point must be installed in the primary refrigerant flow by flame brazing into the suction pipe work, and - if Schrader copper pipe fittings are used, they must not be inserted no more than 2 mm into the pipe work.		- System diagram - Manufacturers instructions
			No	Performance below industry norm: The pressure control is NOT piped: per manufacturer instructions,		

				• per project system diagram, • into the correct location, or • with access for service and adjustment.		
3.16 Pressure gauge and its hand valve	M	4	Yes	Performance meets industry benchmark. They are installed • per manufacturer instructions and • in the correct location in system, • so that pressure sensing point must be in the primary refrigerant flow circuit, and must always sense pressure, • so as not to trap oil in the connecting pipe work, and • mounted securely.		• System diagram • Ruler • Tape measure • Template • Manufacturer's installation instructions
			No	Performance below industry norm. They are NOT installed: • per manufacturer instructions • in the correct location in system, • so that pressure sensing point must be in the primary refrigerant flow circuit, and must always sense pressure, or mounted securely.		

ELECTRICAL CABLE INSTALLATION

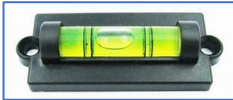
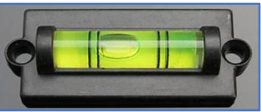
ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
4.1 Electrical supply plug	J	4	Yes	Performance meets industry benchmark: - The electrical supply is wired to the correct pins on the plug, - The stripped wires are securely fastened to the pins, with no exposed strands - The correct colour and current capacity rated cable is used, and - The cable is securely fastened to the plug	 	- Manufacturer's installation instructions - Relevant Standard
			No	Performance below industry norm: - The electrical supply is NOT wired to the correct pins on the plug, - The stripped wires are NOT securely fastened to the pins, Major exposed strands, - The incorrect colour and current capacity rated cable is used or - The cable is NOT securely fastened to the plug.	 	
4.2 Control board electrical supply	M	4	Yes	Performance meets industry benchmark: - The 220V supply is wired to the correct terminals, - The wiring is correctly and securely terminated, with no exposed strands - The correct colour and current capacity rated cable is used, and - The cable is securely fastened.		Project circuit diagram

			No	Performance below industry norm: - The 220V supply is NOT wired to the correct terminals, - The wiring is NOT correctly and securely terminated, or with major exposed strands, - The incorrect colour and current capacity rated cable is used.		
4.3 Compressor wiring	M	4	Yes	Performance meets industry benchmark: - The compressor is wired to correct terminals in control board and compressor starting kit, - The wiring is correctly and securely terminated with no exposed strands, - The correct colour and current capacity rated cable is used, and - The cable is securely fastened.		- Project circuit diagram - Manufacturer's installation instructions
			No	Performance below industry norm: - The compressor is NOT wired to correct terminals in control board and compressor starting kit, - The wiring is NOT correctly and securely terminated, or with major exposed strands, - The incorrect colour and current capacity rated cable is used.		
4.4 Condenser fan motor wiring	M	4	Yes	Performance meets industry benchmark: - The wiring is connected to the correct terminals of the motor and the control board, - The wiring is correctly and securely terminated with no exposed strands, - The correct colour and current capacity rated cable is used, and - The cable is securely fastened.		- Project circuit diagram - Manufacturer's installation instructions

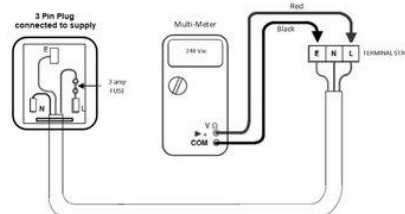
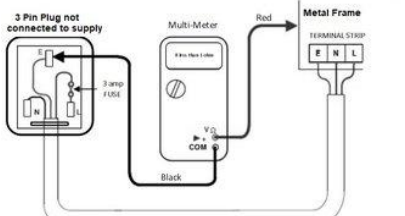
			No	Performance below industry norm: • The wiring is NOT wired to correct terminals of the motor and the control board, • The wiring is NOT correctly and securely terminated, with major exposed strands, or • The cable is NOT securely fastened, • The incorrect colour and current capacity rated cable is used.		
4.5 Solenoid valve	M	4	Yes	Performance meets industry benchmark: • The wiring is connected to the correct terminals of the valve coil and the control board, • The wiring is correctly and securely terminated, with no exposed strands, • The correct colour and current capacity rated cable is used, and • The cable is securely fastened.		• Project circuit diagram • Manufacturer's installation instructions
			No	Performance below industry norm: • The wiring is NOT wired to correct terminals of the valve coil and the control board • The wiring is NOT correctly and securely terminated, or with major exposed strands. • The cable is NOT securely fastened, • The incorrect colour and current capacity rated cable is used.		

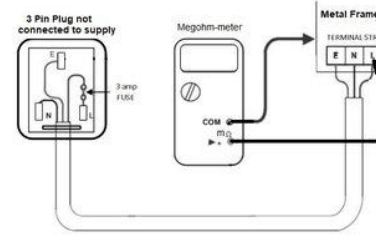
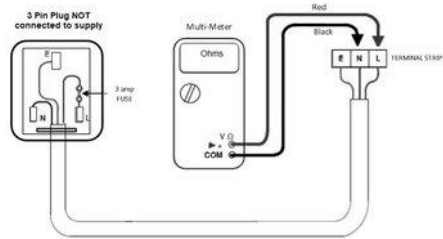
4.6 Dual pressure control	M	4	Yes	Performance meets industry benchmark: - The wiring is connected to the correct terminals of the dual pressure control and the control board, - The wiring is correctly and securely terminated with no exposed strands, - The correct colour and current capacity rated cable is used, and - The cable is securely fastened.		- Project circuit diagram - Manufacturer's installation instructions
			No	Performance below industry norm: - The wiring is NOT wired to correct terminals of the dual pressure control and the control board, - The wiring is NOT correctly and securely terminated, with major exposed strands, - The cable is NOT securely fastened, or - The incorrect colour and current capacity rated cable is used.		
4.7 High pressure control	M	4	Yes	Performance meets industry benchmark: - The wiring is connected to the correct terminals of the high-pressure control and the control board, - The wiring is correctly and securely terminated with no exposed strands, - The correct colour and current capacity rated cable is used, and - The cable is securely fastened.		- Project circuit diagram - Manufacturer's installation instructions

			No	Performance below industry norm: • The compressor is NOT wired to correct terminals of the high-pressure control and the control board, • The wiring is NOT correctly and securely terminated, or with major exposed strands. • The incorrect colour and current capacity rated cable is used.		
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ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
4.8 Cable and/or pipe duct cover (channel)	J	4	3	Performance meets industry benchmark and is judged as excellent: - The duct is installed securely vertically and horizontally with the spirit level bubble within the inner lines, - Cuts have a smooth finish without burrs, and - Corners are cut at 45° +/- 2°	 	- Project diagrams - Spirit level - Digital Sliding T-Bevel Gauge and Protractor 
			2	Performance meets industry criterion and surpasses that standard to some extent: - The duct is installed securely vertically or horizontally with the spirit level bubble within the inner lines, - Cuts have a smooth finish without burrs, and - Corners are cut at 45° +/- 4°	 	
			1	Performance meets industry benchmark: - The duct is installed securely vertically or horizontally with the spirit level bubble within the outer lines, - Cuts have a smooth finish without burrs, and - Corners are cut at 45° +/- 4°	 	
			0	Performance below industry norm: - The duct is NOT installed securely vertically or horizontally with the spirit level bubble within the outer lines, - Cuts do NOT have a smooth finish without burrs, or - Corners are NOT cut at 45° +/- 4°	  	

ELECTRICAL TESTING AND FAULT FINDING

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
5.1 Supply voltage to earth and/or neutral	M	5	Yes	Performance meets industry benchmark: - voltage was safely and accurately measured and, recorded at site supply voltage +/- 10% rating with correct meter and range scale, - selected appropriate voltage instrument and scale, - used correct PPE, and - did not trip the circuit breaker.		- Voltmeter - Range = Volts AC - Scale 500 volt
			No	Performance below industry norm: - voltage was NOT safely and accurately measured and recorded at site supply voltage +/- 10% rating with correct meter or range scale, - did not select appropriate instrument and voltage scale, - did not used correct PPE, or - did trip the circuit breaker.		
5.2 Earth continuity resistance to control board and loads	M	5	Yes	Performance meets industry benchmark: - earth continuity of the power supply to the control board and loads was safely and accurately tested, recorded, less than 1 ohm, to one (1) decimal place, - isolated electrical supply - selected appropriate instrument and Ohm resistance scale, - did not put fingers on the test probes during measurement.		- Low Reading Ohm-meter - Range = Lowest Ohms scale available
			No	Performance below industry norm: earth continuity of the power supply to the control board and loads was NOT safely and accurately tested, recorded, less than 1 ohm, to one (1) decimal place,		

				• did not isolate electrical supply • did not select appropriate instrument and Ohm resistance scale, or • put fingers on the test probes during measurement		
5.3 Earth leakage insulation test	M	6	Yes	Performance meets industry benchmark: • installation was safely and accurately tested and recorded for earth leakage using a Megohm-meter prior to energizing, greater than 2 meg-ohm, • isolated electrical supply, • isolated any electronic components (if possible), • selected appropriate instrument and voltage scale (2 times operating voltage), • did not put fingers on the test probes during measurement		• Megohm-meter/ Insulation Tester • Range = 500 volt or 250 volt for electronic equipment
			No	Performance below industry norm: • installation was NOT safely and accurately tested and recorded for earth leakage using a Megohm-meter prior to energizing, OR less than 2 meg-ohm • did not isolate electrical supply • did not isolate electronic components • selected appropriate instrument and voltage scale (2 times operating voltage), • put fingers on the test probes during measurement		
5.4 Short circuits resistance test	M	6	Yes	Performance meets industry benchmark: • installation was safely and accurately tested and recorded for shorts between active and neutral prior to energizing and found to be greater than 100 ohms, • isolated electrical supply, • selected appropriate resistance instrument and scale, • did not put fingers on the test probes during measurement		• Ohm-meter • Range = Ohms • Scale less than 100 ohms
			No	Performance below industry norm:		

				• installation was NOT safely and accurately tested and recorded for shorts between active and neutral prior to energizing and found not to be at less than 100 ohms, • did not isolate electrical supply, • did not select appropriate resistance instrument and scale, or • put fingers on the test probes during measurement		
5.5 Electrical resistance	M	6	Yes	Performance meets industry benchmark: • electrical resistance of a load component is safely and accurately measured and recorded to OEM values +/- 5%, • isolated electrical supply, • selected appropriate resistance instrument and scale, • did not put fingers on the test probes during measurement		• Ohm-meter • Range = Ohms • Scale less than 500 ohms
			No	Performance below industry norm: • electrical resistance of a load component is NOT safely and accurately measured and recorded to OEM values, +/- 5%, • did not isolate electrical supply, • did not select appropriate resistance instrument and scale, or • put fingers on the test probes during measurement		
5.6 Operating current	M	6	Yes	Performance meets industry benchmark: • operating current of a load component or circuit is safely and accurately measured and recorded to OEM values, +/- 5%, • selected appropriate amperage instrument and scale, • did not come in contact with supply voltage, and • did not trip the circuit breaker		• Tong-ammeter or Clamp Amp meter • Scale less than 50 Amps
			No	Performance below industry norm:		

				- operating current of a load component or circuit is safely and accurately measured and recorded to OEM values, +/- 5%, - did not select appropriate amperage instrument and scale, - did come in contact with supply voltage, or - did trip the circuit breaker.		
5.7 Electrical fault finding	J	6	3	Performance meets industry criterion and surpasses that standard to some extent: - electrical circuit or component was safely tested for faults, - selected appropriate test instruments and scales, - used the correct PPE, - did not trip the circuit breaker, and - electrical faults were identified within the 50% of the maximum time permitted		- Multi-meter - Range = Ohms - Scale less than 500 ohms - Circuit diagram
			2	Performance meets industry criterion and surpasses that standard to some extent: - electrical circuit or component was safely tested for faults, - selected appropriate test instruments and scales, - used the correct PPE, - did not trip the circuit breaker, and - electrical faults were identified within the 75% of the maximum time permitted		
			1	Performance meets industry criterion and surpasses that standard to some extent: - electrical circuit or component was safely tested for faults, - selected appropriate test instruments and scales, - used the correct PPE, - did not trip the circuit breaker, and - electrical faults were identified within the maximum time permitted		

			0	Performance below criterion norm: - electrical circuit or component was NOT safely tested for faults, - did not select appropriate test instruments and scales, - did not use the correct PPE, - tripped the circuit breaker, or - electrical faults were NOT identified in allowable time		
5.8 Electrical fault repair	M	6	Yes	Performance meets industry benchmark and is judged as excellent: - electrical faulty circuit or component was safely repaired/replaced, - isolated electrical supply, - used the correct PPE, - did not trip the circuit breaker, and - electrical fault was rectified within the maximum time permitted		- Multi-meter - Circuit diagram
			No	Performance is below industry criterion and does NOT surpasses that standard: - electrical faulty circuit or component was NOT safely repaired/replaced, - did not isolated electrical supply, - did not use the correct PPE, - did trip the circuit breaker, and - electrical fault was rectified not repaired within time permitted		
5.9 Energizing circuit	M	6	Yes	Performance meets industry benchmark: - circuit was energized safely the first time without blowing fuses/circuit breakers/etc, and - used the correct PPE		Circuit breaker
			No	Performance below industry norm:		

				• circuit was NOT energized safely the first time or it blew fuses/circuit breakers/etc, or • did not used the correct PPE		
5.10 Circuit's first operation	M	6	Yes	Performance meets industry benchmark: • circuit worked safely and correctly per circuit diagram the first time it was operated without wiring modifications, • used the correct PPE, and • did not trip the circuit breaker		• Circuit diagram
			No	Performance below industry norm: • circuit did NOT work safely and correctly per circuit diagram the first time it was operated without wiring modifications • did not used the correct PPE, and • tripped the circuit breaker		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
5.11 Circuit's final operation	M	6	Yes	Performance meets industry benchmark: • circuit worked safely and correctly per circuit diagram after any necessary, if any modifications were completed • used the correct PPE, and • tripped the circuit breaker		• Circuit diagram
			No	Performance below industry norm: • circuit did NOT work safely and correctly per circuit diagram after any necessary, if any modifications were completed • did not used the correct PPE, and • tripped the circuit breaker		

PRESSURE TESTING

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
6.1 Test Pressure	M	3	Yes	Performance meets industry benchmark: - The test pressure during all attempts met required standards and specifications, <i>Test pressure shall be equivalent to a saturation temperature between 53.5°C and 55°C, and shall not exceed 55°C for the high-pressure side, provided the high side can be fully isolated from the low side.</i> Test pressure is equivalent to not less than 32 °C saturation temperature of the low-side and no more, for the entire system when unable to isolate from the high side of the system.	Example, 55°C to 53.5 °C saturation temperature on R134a = 1,390 kPa to 1335 kPa or 202 PSI to 198 PSI 32°C saturation temperature on R134a = 714 kPa to 694 kPa or 104 PSI to 101 PSI	- Refrigerant type - Pressure /Temperature Chart
			No	Performance below industry norm: - The test pressure during all attempts does NOT meet required standards and specifications, - Test pressure is NOT equivalent to 55°C saturation temperature for the high-pressure side, if the high side can be isolated. - Test pressure is NOT equivalent to 32°C saturation temperature for the low-pressure side		
6.2 System valves open	M	4	Yes	Performance meets industry benchmark: - All the appropriate valves were opened to ensure pressure testing of the entire system - These include service valves, solenoid valves, line valves, ball valve, post valves, receiver valves.		- Manifold gauges - System piping diagram
			No	Performance below industry norm: - All the appropriate valves were NOT opened to ensure pressure testing of the entire system - These include service valves, solenoid valves, line valves, ball valve, post valves, receiver valves.		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	ASSESSMENT TOOLS
6.3 Gauges fitted	M	4	Yes	Performance meets industry benchmark: • The gauge manifold and gauge lines correctly fitted to access/service valves on both sides of the system, if possible • The gauge manifold and hoses must be evacuated not purged with refrigerant to remove the air where service valves are present • The gauge manifold and hoses can be purged with minimal amount of vapour (1 second or less) refrigerant to remove the air where service valves are NOT present • The high-pressure gauge is connected to the correct high-pressure side access/service valve port of the system • The low-pressure gauge is connected to the correct low-pressure side access/service valve port of the system • The centre/yellow gauge line of the manifold has been connected to an accessory correctly (vacuum pump, gas bottle, regulator, recovery unit) if used or sealed off on the manifold. • With services valves open to the system if fitted • Gauges lines and gauge manifold were leak tested.	• System piping diagram • Manifold gauges
			No	Performance below industry norm: • The gauge manifold and gauge lines NOT correctly fitted to access/service valves on both sides of the system, if possible • The gauge manifold and hoses have NOT been evacuated but purged with refrigerant vapour (greater than 1 second) to remove the air where service valves are present • The gauge manifold and hoses have NOT been purged with minimal amount of vapour (greater than 1 second) refrigerant to remove the air where service valves are NOT present • The high-pressure gauge is NOT connected to the correct high-pressure side access/service valve port of the system • The low-pressure gauge is NOT connected to the correct low-pressure side access/service valve port of the system • The centre/yellow gauge line of the manifold has NOT been connected to an accessory correctly (vacuum pump, gas bottle, regulator, recovery unit) if used or NOT sealed off on the manifold. • With services valves NOT open to the system if fitted • Gauges lines and gauge manifold were NOT leak tested.	
6.4	M	4	Yes	Performance meets industry benchmark:	

Dry Nitrogen added for pressure test				• Dry Nitrogen was safely added to the system to the required test pressure in stages of approx. 50%, 75% and 100% • Leak test between staged pressure increases to confirm no leaks • Excessive pressure (Above Aspect 6.1 limits) was not added to the system • No connecting hoses or fittings leaked	• Manifold gauges • Oxygen free nitrogen • System test pressure per Test Project requirements
			No	Performance below industry norm: • Dry Nitrogen was NOT purged though the centre (yellow) line from the regulator to the system before opening service valves. • Dry Nitrogen was NOT safely added to the system to the required test pressure in stages of approx. 50%, 75% and 100% • Did not leak test between staged pressure increases to confirm no leaks • Excessive pressure (Above Aspect 6.1 limits) was added to the system • Connecting hoses or fittings leaked	

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
6.5 Leak test	M	4	Yes	Performance meets industry benchmark: • the system was leak tested while under the required pressure using soap/water solution • location of all leaks were identified		• Soup/water solution or leak test fluid
			No	Performance below industry norm: • the system was NOT leak tested or under the required test pressure using soap/water solution • location of all leaks were NOT identified		
6.6 First leak test	M	4	Yes	Performance meets industry benchmark: • There were No leaks detected on FIRST pressure test, • System pressure did not drop equivalent of 1K over a given period of 15 minutes.		• Soup/water solution or leak test fluid
			No	Performance below industry norm: • There were leaks detected on FIRST pressure test,		

				System pressure did drop the equivalent of 1K or more over a given period 15 minutes.		
6.7 Final leak test	M	4	Yes	Performance meets industry benchmark: - The system held the test pressure for required standing time (15 minutes) after any leaks were repaired - Test pressure did NOT drop more than equivalent of 1°C from the starting point in the fifteen (15) minutes after the system is isolated from the Nitrogen cylinder.	Example, 55°C saturation temperature on R134a = 1,390 kPa or 202 PSI 54°C saturation temperature on R134a = 1,354 kPa or 196 PSI - Therefore the pressure must no drop more than 1,390 kPa - 1,354 kPa = 36 kPa, - or 202 PSI - 196 PSI = 6PSI	- Soup/water solution or leak test fluid - Clock or stop watch
			No	Performance below industry norm: - The system did NOT hold the test pressure for required standing time (15 minutes) after any leaks were repaired - Test pressure dropped more than equivalent of 1°C from the starting point in the fifteen (15) minutes after the system is isolated from the Nitrogen cylinder.		
6.8 Pressure release	M	4	Yes	Performance meets industry benchmark: - Dry Nitrogen was slowly and safely released from system into a rag at completion of pressure test - No gauge hoses swung around, or audible noise generated by the release of the Nitrogen.		Manifold gauges
			No	Performance below industry norm: - Dry Nitrogen was NOT slowly and safely release into a rag from system at completion of pressure test - Gauge hoses swung around, or excessive audible noise generated by the release of the Nitrogen.		

EVACUATION

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
7.1 System valves open	M	4	Yes	Performance meets industry benchmark: - All the appropriate valves were opened to ensure evacuation of the entire system - These include service valves, solenoid valves, line valves, ball valve, post valves, receiver valves		- System piping diagram - Manifold gauges
			No	Performance below industry norm: All the appropriate valves (above) were NOT opened to ensure evacuation of the entire system		
7.2 Vacuum pump and vacuum gauges connection	M	4	Yes	Performance meets industry benchmark: Vacuum pump and vacuum gauges were connected to the system correctly	Vacuum gauge must be installed so it could be isolated from the vacuum pump and still measure the system's pressure	- System piping diagram - Manifold gauges
			No	Performance below industry norm: Vacuum pump and vacuum gauges were NOT connected to the system correctly		
7.3 Vacuum pressure, first attempt	M	4	Yes	Performance meets industry benchmark: system reached the required vacuum level of at least or equal to 1000 microns on the first attempt		- Manifold gauges - Vacuum gauge
			No	Performance below industry norm: system did NOT reach the required vacuum level of at least 1000 microns on the first attempt		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
7.4 Vacuum holding pressure, first attempt	M	4	Yes	Performance meets industry benchmark: • vacuum achieved 1000 microns or below at the commencement of the test period and did not rise above 1500 microns in 10 minutes when isolated from the vacuum pump, after the FIRST attempt		• Vacuum gauge • Manifold gauges • Clock or stop watch
			No	Performance below industry norm: • vacuum was not achieved or did rise more than 1500 microns in 10 minutes when isolated from the vacuum pump, after the FIRST attempt		
7.5 Final vacuum holding pressure	M	4	Yes	Performance meets industry benchmark: • system reached vacuum of at least or below 1000 microns and did not rise to above 1500 microns in 10 minutes when isolated from the vacuum pump, on the final attempt		• Vacuum gauge • Manifold gauges • Clock or stop watch
			No	Performance below industry norm: • system did NOT reach vacuum below 1000 microns or it rose to more than 1500 microns in 10 minutes when isolated from the vacuum pump, on the final attempt		

REFRIGERANT CHARGING

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
8.1 Gauge manifold connection	M	5	Yes	Performance meets industry benchmark: • The gauge manifold and gauge lines correctly fitted to access/service valves on both sides of the system, if possible • The gauge manifold and hoses must be evacuated not purged with refrigerant to remove the air where service valves are present • The gauge manifold and hoses can be purged with minimal amount (1 second or less) of vapour refrigerant to remove the air where service valves are NOT present • The high-pressure gauge is connected to the correct high-pressure side access/service valve port of the system • The low-pressure gauge is connected to the correct low-pressure side access/service valve port of the system • The centre/yellow gauge line of the manifold has been connected to an accessory correctly (vacuum pump, gas bottle, regulator, recovery unit) if used or sealed off on the manifold. • With services valves open to the system if fitted Gauges lines and gauge manifold were leak tested.		• System piping diagram • Manifold gauges
			No	Performance below industry norm: • The gauge manifold and gauge lines NOT correctly fitted to access/service valves on both sides of the system, if possible • The gauge manifold and hoses have NOT been evacuated but purged with refrigerant vapour (more than 1 second) to remove the air where service valves are present		

				• The gauge manifold and hoses have NOT been purged with minimal amount (more than 1 second) of vapour refrigerant to remove the air where service valves are NOT present • The high-pressure gauge is NOT connected to the correct high-pressure side access/service valve port of the system • The low-pressure gauge is NOT connected to the correct low-pressure side access/service valve port of the system • The centre/yellow gauge line of the manifold has NOT been connected to an accessory correctly (vacuum pump, gas bottle, regulator, recovery unit) if used or NOT sealed off on the manifold. • With services valves NOT open to the system if fitted • Gauges lines and gauge manifold were NOT leak tested.		
8.2 Refrigerant cylinder weight	M	6	Yes	Performance meets industry benchmark: • refrigerant cylinder weight was accurately measured and recorded correctly before charging started		• Manifold gauges • Refrigerant scale
			No	Performance below industry norm: • refrigerant cylinder weight was NOT accurately measured and recorded correctly before charging started		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	• ASSESSMENT TOOLS
8.3 Refrigeration system's valves	M	5	Yes	Performance meets industry benchmark: • all refrigeration system's access and line valves were in correct position to charge the system with refrigerant		• System piping diagram • Manifold gauges
			No	Performance below industry norm: • all refrigeration system's access and line valves were NOT in correct position to charge the system with refrigerant		
8.4 Adding liquid refrigerant	M	5	Yes	Performance meets industry benchmark: • liquid refrigerant was added to the system using correct method with no or minimal loss (1 second or less) of refrigerant to the atmosphere		• Manifold gauges
			No	Performance below industry norm: • liquid refrigerant was NOT added to the system using correct method or with loss (more than 1 second) of refrigerant to the atmosphere		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
8.5 Adding vapour refrigerant	M	5	Yes	Performance meets industry benchmark: vapour of non-blend refrigerant was added to the system using correct method with no or minimal loss (1 second or less) of refrigerant to the atmosphere		- Manifold gauges - Refrigerant scale
			No	Performance below industry norm: vapour of non-blend refrigerant was NOT added to the system using correct method or with loss (more than 1 second) of refrigerant to the atmosphere		
8.6 Initial refrigerant quantity	M	5	Yes	Performance meets industry benchmark: - adequate refrigerant was added to the system to ensure its effective operation - total refrigerant quantity charged into system is as specified, +/- 5%		- Manifold gauges - Refrigerant scale
			No	Performance below industry norm: - Adequate refrigerant was NOT added to the system to ensure its effective operation - total refrigerant quantity charged into system was not as specified, +/- 5%		
8.7 Service gauge removal	M	5	Yes	Performance meets industry benchmark: services gauges were removed from the system and the bottle after pumping down the system to reduce the pressure to 5-10 kPa to ensure minimal loss (1 second or less) of refrigerant released to atmosphere		Manifold gauges
			No	Performance below industry norm: services gauges were NOT removed from the system and the bottle with liquid refrigerant released (more than 1 second) or system was in a vacuum.		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
8.9 Leak test	M	5	Yes	Performance meets industry benchmark: • electronic leak test was carried out during or after the charging of refrigerant and after gauge removal, all leaks rectified		• Soup/water solution or leak test fluid • Electronic leak detector
			No	Performance below industry norm: • An electronic leak test was NOT carried out during or after the charging of refrigerant or removal of gauges, leaks not rectified.		

COMMISSIONING AND FAULT FINDING

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	ASSESSMENT TOOLS
9.1 Refrigerant type	M	5	Yes	Performance meets industry benchmark: • Correct refrigerant type was selected and recorded correctly on the commissioning report	• System specifications
			No	Performance below industry norm: • Correct refrigerant type was NOT selected and/or recorded correctly on the commissioning report	
9.2 Refrigerant charge	M	5	Yes	Performance meets industry benchmark: • refrigerant charge was measured and recorded correctly on the commissioning report, +/- 5%	• System specifications
			No	Performance below industry norm: • refrigerant charge was NOT measured and recorded correctly on the commissioning report, +/- 5%	
9.3 Operating Temperatures	M	5	Yes	Performance meets industry benchmark: • dry bulb temperatures were measured and recorded correctly on commissioning report, +/- 1K	• Digital thermometer
			No	Performance below industry norm: • dry bulb temperature was NOT measured and recorded correctly on commissioning report, +/- 1K	
9.4 Operating pressures	M	5	Yes	Performance meets industry benchmark: • operating pressures was measured and recorded correctly on the commissioning report, +/- 5%	• Pressure gauges
			No	Performance below industry norm: • operating pressures was NOT measured and recorded correctly on the commissioning report, +/- 5%	

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	ASSESSMENT TOOLS
9.5 Superheat	M	5	Yes	Performance meets industry benchmark: • superheat was determined and recorded correctly on the commissioning report, +/- 1K	- Digital thermometer - Pressure gauges
			No	Performance below industry norm: • superheat was NOT determined and recorded correctly on the commissioning report, +/- 1K	
9.6 Operating current	M	5	Yes	Performance meets industry benchmark: • operating current was measured and recorded correctly on the commissioning report, +/- 5%	• Tong ammeter
			No	Performance below industry norm: • operating current was NOT measured and recorded correctly on the commissioning report, +/- 5%.	
9.7 Motor contactor overload setting	M	5	Yes	Performance meets industry benchmark: • motor contactor overload setting was determined, set and recorded correctly on the commissioning report, +/- 5%	• Motor Full Load Amperage rating
			No	Performance below industry norm: motor contactor overload setting was determined set and recorded correctly on the commissioning report, +/- 5%	
9.8 Temperature control settings	M	5	Yes	Performance meets industry benchmark: • temperature control setting was determined, set and recorded correctly on the commissioning report, per the module specifications	• System specifications
			No	Performance below industry norm: • temperature control setting was NOT determined, set and recorded correctly on the commissioning report, per the module specifications	

9.9 Pressure control settings	M	5	Yes	Performance meets industry benchmark: pressure control settings were determined correctly, set and recorded correctly on the commissioning report, per the module specifications +/- 1K	System specifications
			No	Performance below industry norm: pressure control settings were NOT determined, set and recorded correctly on the commissioning report, per the module specifications +/- 1K	
9.10 Fitting service gauges to charged system	M	6	Yes	Performance meets industry benchmark: - The gauge manifold and gauge lines correctly fitted to access/service valves on both sides of the system, if possible - The gauge manifold and hoses must be evacuated not purged with refrigerant (1 second or less) to remove the air where service valves are present - The gauge manifold and hoses can be purged with minimal amount (1 second or less) of vapour refrigerant to remove the air where service valves are NOT present - The high-pressure gauge is connected to the correct high-pressure side access/service valve port of the system - The low-pressure gauge is connected to the correct low-pressure side access/service valve port of the system - The centre/yellow gauge line of the manifold has been connected to an accessory correctly (vacuum pump, gas bottle, regulator recovery unit) if used or sealed off on the manifold. - With services valves open to the system if fitted - Gauges lines and gauge manifold were leak tested.	Services gauges
			No	Performance below industry norm: - The gauge manifold and gauge lines NOT correctly fitted to access/service valves on both sides of the system, if possible - The gauge manifold and hoses have NOT been evacuated but purged with refrigerant (more than 1 second) to remove the air where service valves are present - The gauge manifold and hoses have NOT been purged with minimal amount (more than 1 second) of vapour refrigerant to remove the air where service valves are NOT present - The high-pressure gauge is NOT connected to the correct high-pressure side access/service valve port of the system - The low-pressure gauge is NOT connected to the correct low-pressure side access/service valve port of the system	

				• The centre/yellow gauge line of the manifold has NOT been connected to an accessory correctly (vacuum pump, gas bottle, regulator recovery unit) if used or NOT sealed off on the manifold. • With services valves NOT open to the system if fitted • Gauges lines and gauge manifold were NOT leak tested.	
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ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	• ASSESSMENT TOOLS
9.11 Refrigeration fault finding	J	6	3	Performance meets industry benchmark and is judged as excellent: • refrigeration system or component was safely tested for faults • faults were identified and readings confirmed fault within half of the maximum time permitted		• System specifications and drawings
			2	Performance meets industry criterion and surpasses that standard to some extent: • refrigeration system or component was safely tested for faults • faults were identified and readings confirmed fault in $\frac{3}{4}$ of the maximum time permitted		
			1	Performance meets industry benchmark: • refrigeration system or component was safely tested for faults • faults were identified and readings confirmed fault within the maximum time permitted		
			0	Performance below industry norm: • refrigeration system or component was NOT safely tested for faults • faults were NOT identified or readings did not confirmed correct fault		
9.12 Refrigeration fault repair	J	6	3	Performance meets industry benchmark and is judged as excellent: • refrigeration fault or component was safely repaired/replaced, and • refrigeration fault was rectified within 50% of the maximum time permitted		

			2	Performance meets industry criterion and surpasses that standard to some extent: • refrigeration fault or component was safely repaired/replaced, and • refrigeration fault was rectified within 75% of the maximum time permitted		
			1	Performance meets industry benchmark: • refrigeration fault or component was safely repaired/replaced, and • refrigeration fault was rectified within the maximum time permitted		
			0	Performance below industry norm: • refrigeration fault or component was NOT safely repaired/replaced, or • refrigeration fault was NOT rectified within the maximum time permitted		

REFRIGERANT RECOVERY

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
10.1 Refrigerant cylinder selection	M	6	Yes	Performance meets industry benchmark: • correct refrigerant recovery cylinder was selected and used		
			No	Performance below industry norm: • correct refrigerant recovery cylinder was NOT selected and used		
10.2 Refrigerant cylinder weight	M	6	Yes	Performance meets industry benchmark: • refrigerant recovery cylinder was weighed and recorded correctly before recovery started		• Electronic scales
			No	Performance below industry norm: • refrigerant recovery cylinder was NOT weighed and recorded correctly before recovery started		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	• ASSESSMENT TOOLS
10.3 Recovery system connections	M	6	Yes	Performance meets industry benchmark: • refrigerant recovery cylinder, machine and lines were connected correctly the first time with minimal loss (1 second or less) of refrigerant released to atmosphere		• Refrigerant recovery unit and cylinder
			No	Performance below industry norm: • refrigerant recovery cylinder, machine and lines were NOT connected correctly the first time with minimal loss (more than 1 second) of refrigerant released to atmosphere		
10.4 Refrigerant recovery	M	6	Yes	Performance meets industry benchmark: • the full refrigerant charge was recovered from the system using recovery equipment • system pressure/s were at atmospheric pressure or just below (0 psi to -5 psi/0 kPa to -35 kPa) after recovery was completed		• Refrigerant recovery unit and cylinder
			No	Performance below industry norm: • the full refrigerant charge was NOT recovered from the system using recovery equipment • system pressure/s were NOT at atmospheric pressure or just below (0 psi to -5 psi/0 kPa to -35 kPa) after recovery was completed		
10.5 Refrigerant leak test	M	6	Yes	Performance meets industry benchmark: • electronic leak detector was used to check for leaks during recovery of refrigerant		• Electronic leak detector • Soap water solution
			No	Performance below industry norm: • electronic leak detector was NOT used to check for leaks during recovery of refrigerant		

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	• ASSESSMENT TOOLS
10.6 Disconnection of recovery equipment	M	6	Yes	Performance meets industry benchmark: • recovery equipment was disconnected with minimal (1 second or less) loss of refrigerant and all service caps fitted		
			No	Performance below industry norm: • recovery equipment was NOT disconnected with minimal (more than 1 second) loss of refrigerant and all service caps were NOT fitted		
10.7 Recovered refrigerant quantity	M	6	Yes	Performance meets industry benchmark: • quantity of refrigerant recovered from the system was correctly recorded		
			No	Performance below industry norm: • quantity of refrigerant recovered from the system was NOT correctly recorded		

WORK PRACTICES AND SAFETY

ASPECT	ASPECT TYPE	WSOS section	SCORE	DESCRIPTOR	RESOURCE	ASSESSMENT TOOLS
11.1 Protective gloves	M	1		Number of times protective gloves were NOT worn and arms were NOT covered when exposed to heat sources		Competitors Work Practices and Safety record form
11.2 Protective eye wear	M	1		Number of times protective eye wear was NOT worn while cutting, flaring, pressure testing, evacuation/charging, live electrical work, and brazing		
11.3 Tools and equipment used safely and safe work practices	M	1		Number of times the competitor did NOT use the correct tools for the correct purpose and safe work practices. The competitor's tools, equipment and work area (booth) were in a safe condition on completion of module times.		
11.4 Brazing torches and regulators and cylinders	M	1		Number of times the competitor's brazing torches and regulators were NOT left at atmospheric pressure and ALL bottles isolated during non-competition times		
11.5 Pipe and equipment isolations.	M	1		Number of times the competitor has NOT replaced caps on vacuum pumps, recovery unit, refrigerant cylinders, condenser unit service valves, the end of refrigerant pipes and fitting when not in use or at the completion of the module times.		
11.6 Dry Nitrogen (N2)	M	1		Number of times the competitor did NOT have N2 bottle secured, regulator used, N2 flow while use of silver brazing or use Dry Nitrogen correctly during silver brazing		