WorldSkills International, by a resolution of the Technical Committee and in accordance with the Constitution, the Standing Orders and the Competition Rules, has adopted the following minimum requirements for this skill for the WorldSkills Competition.

The Technical Description consists of the following:

Effective 31.03.10

Liam Corcoran
Technical Committee Chair

1. INTRODUCTION

1.1 Name and description of skill

The name of the skill is Plumbing & Heating.

1.1.1 Description of skill

Plumbers install water, sanitation, drainage and heating pipes for houses and industrial sites. The tasks can include natural and manufactured gas and compressed air pipe installations.

Pipes may be welded, soft-soldered, hard-soldered, threaded and jointed using proprietary fittings. Pipe jointing by machine crimping may also be utilised. Pipe bending may be carried out by hydraulically operated or hand operated bending machines and by applying heat (Black Mild Steel Pipe only) with the bending angles only being measured for machine made bends and the radii and angles being measured for heat made bends.

The installation and fixing of the pipes to various building components is an integral component of the skill, as is the installation of terminal fittings, sanitary and heating appliances and components e.g. showers, basins, WCs, boilers, radiators and circulators.

1.2 Scope of application

1.2.1 Every Expert and Competitor must know this Technical Description.

1.2.2 In the event of any conflict within the different languages of the Technical Descriptions, the English version takes precedence.

1.3 Associated documents

1.3.1 As this Technical Description contains only skill-specific information it must be used in association with the following:

- WSI - Competition Rules
- WSI - Competition Manual
- WSI - Online resources as indicated in this document
- Host Country - Health and Safety regulations

2. COMPETENCY AND SCOPE OF WORK

The Competition is a demonstration and assessment of the competencies associated with this skill. The Test Project consists of practical work only.

2.1 Competency specification

A Competitor in Plumbing and Heating must be able to

- Read and interpret a plumbing and heating pipe-work and appliance drawing;
- Understand the drawing notation and the pipe-work, fittings and appliance symbols
- Interpret the drawing layout to facilitate pipe-work fabrication and appliance installation
- Transfer the given dimensions from the project drawing to the workstation surfaces

Work safely at all times

- Select and use the appropriate personal protective equipment for every task
- Select and utilise the appropriate hand tools to undertake every task safely
- Utilise the appropriate precautions when gas welding or soldering
- Utilise the specified precautions for lifting heavy or long pieces of equipment
- Utilise the specified precautions for working with electrical powered hand tools

Install plumbing and heating pipe-work brackets/clips
- Select a suitable fixing method for the workstation fabric and pipe/appliance weight
- Fix the correct number and diameter of pipe brackets/clips in the correct configuration
- Fix the sanitary/heating appliance brackets in the correct configuration

Prefabricate the required pipe-work layouts into sub assemblies to facilitate installation
- Determine the optimum way to use the given material to ensure module completion
- Limit and avoid scrap/waste generation
- Determine the correct positions for cutting the piping material
- Determine the correct positions for bending the piping material
- Select an appropriate and safe method for cutting the piping material
- Utilise the specified bending method to safely bend the piping material
- Utilise the specified jointing method to form the pipe-work sub assemblies

Install, connect and test completed pipe-work modules
- Install the sanitary/heating appliances to the previously fixed brackets
- Install the pipe-work sub assemblies utilising the previously fixed brackets/clips
- Connect the pipe-work to the sanitary/heating appliances
- Connect the specified test equipment to the pipe-work module
- Maintain the specified pressure and time to pressure test each pipe-work module

Repair, maintain or replace a specified plumbing or heating appliance
- Identify the method of repairing, maintaining or replacing the appliance
- Isolate and drain the water from the appliance
- Perform the necessary repair, maintenance or replacement of the appliance
- Open isolating valves, recharge with water and check for leaks
- Check for correct appliance function

The following competencies are not directly assessed but the Competitor must be to successfully complete the Test Project:
- Taking and transferring measurements and angles from the project drawing to the workstation surfaces and piping materials
- Creating freehand sketches for the purposes of pipe bending and assembly
- Having sufficient knowledge of the safe operation of the cutting, bending, threading, soldering, welding and testing equipment provided
- The ability to understand manufacturer's specifications and drawings
- Having sufficient knowledge of the properties of the piping material supplied in order to successfully handle, cut, bend, joint, and form sub assemblies
- Having sufficient knowledge of the jointing methods, materials and fittings specified in the project drawing to successfully complete a leak free project

2.2 Theoretical knowledge

2.2.1 Theoretical knowledge is required but not tested explicitly

The following theoretical knowledge is required:
- Interpretation and execution of drawings, sketches and diagrams according to recognised industry standards.
- Ability to understand the drawings supplied by Experts and manufacturers specifications.
- Knowledge of plumbing materials and how to process them.

2.2.2 Knowledge of rules and regulations is not examined.

2.3 Practical work

The Competitor must independently carry out the requirements of the following modules using the Host Country's commercially available technical manuals for equipment provided for familiarisation, material and equipment, which must be installed into an installation in accordance with the documentation provided.

Competitors must use the necessary and appropriate working techniques to complete the following technical skills.

- Processing commercial materials into a simple installation according to the drawing, making use of the necessary technical skills.
- Building up part of a gas, water, heating and effluent pipe installation and maintenance of the systems.
- Constructing a sub-assembly of an installation on a prescribed workstation.
- Complying with the standard dimensions given on the project drawing.
- Competitors may use a maximum of 5 handwritten or typed A4 sized sheets of technical information during the Competition.

General

The Competitor must be able to demonstrate a range of skills in the installation of plumbing, heating / piping equipment.

The appropriate technical skills are:

- Measuring, setting out and marking of materials and pipe-work.
- Bending of pipes by machine and by hand.
- Silver soldering (CU) soft soldering (CU) Note: only lead free solders and water based fluxes will be permitted, Crimping/pressing (PE/PEX/PB/CU/SS/composite pipes) fusion joints (PE) and welding (BMS) push-fit rubber ring joints (PVC). Note: the use of solvent welded joints on PVC pipe and cupro-eutectic joints on copper pipe are not permitted
- Connecting by threading, clamping, and compression joints.
- Assembly of pipes and accessories, on a patented metal (steel or aluminium) self-supporting workstation, which could have a backing board attached, the pipes to be fixed by means of an adjustable patented clipping/bracketing system (available in host country) in order to maintain the dimensional accuracy and alignment as indicated on the project drawing.
- Pressure testing using only air, to the prescribed pressures.
- Pre-installed installation of simple plumbing system to permit the repair and maintenance / repair of system components.

Pipe Bending Schedule

- Black Mild Steel
  - By hydraulically operated machine; up to 1˝ diameter
  - By hand/heat; up to ¾˝ diameter (pipe may be sand loaded)
- Copper
  - By hand operated bending machine; up to 25mm diameter
- The Test Project should include at least one bend for each size of pipe specified, formed by utilising each method of bending listed above
- No machine bending of galvanised mild steel pipe to be included in the test project
- Pipe fittings to be utilised as required
- No black or galvanised mild steel pipe above 1¼˝ diameter to be included in the Test Project
- The radius of hand/heat made bends in black mild steel to be a minimum of four times the outside diameter of the pipe.

3. THE TEST PROJECT

3.1 Format / structure of the Test Project

The format of the Test Project is a series of standalone modules.

The project will be in modular format, the minimum number of modules being four, the maximum number being six installed over a 18 -22 hour period. Each module must be completed in the prescribed order and pressure tested within the time allocated for that particular module. Each pressure test must be validated as set out in clause 5.3

The Test Project may contain the following modules:

1 Effluent pipe installation
2 Gas pipe installation
3 Heating installation
4 Cold water installation
5 Hot water installation

3.2 Test Project design requirements

- The accepted project shall reflect current commercial, domestic and industrial plumbing and heating standards and practices.
- The project should be as small as practical and materials available in the host country for sustainability
- Copper pipe supplied by the Host Member must be of a grade that permits bending by hand operated machines.
- All piping materials supplied by the host country must be of uniform wall thickness throughout.
- The use of solvent weld adhesives on PVC pipe-work and components is not permitted.
- The bronze welding of copper pipe and copper fittings is not permitted.
- The work may only involve the use of the following materials:
  - Galvanised, Black Mild Steel, Stainless Steel and light cast iron pipes
  - Copper pipes (half hard temper in straight lengths)
  - Plastic pipes (PE, PEX, PB, HDPE, PP, PVC, composite pipe) for water supply, heating and effluent services
  - Commercially available fittings to suit all piping materials as required
  - Jointing and sealing materials
  - Pipe brackets and fixing materials
  - Leak detection fluid or spray

3.3 Test Project development

The Test Project MUST be submitted using the templates provided by WorldSkills International (http://www.worldskills.org/competitionpreparation). Use the Word template for text documents and DWG template for drawings.

The Test Project must

- Be a Computer Assisted Drawing (CAD) supplied on disk and in hard copy
- Contain a detailed material list. Note: The materials must be available in the host country
- Be self-explanatory requiring a minimum of translation
- Include measurements for the installation of the pipe-work from datum points in the workstation in both the vertical and horizontal directions. The location of these datum points is to be agreed by the Experts and marked on to the workstation by the competition organisers in the host country or workshop supervisor or Experts using laser or digital levelling equipment, prior to the start of the Competition.
- A comprehensive list of materials and components (including the relevant manufacturer's catalogues) for both the pipework and "workstation" components must accompany all projects and must be submitted six months prior to the Competition.

3.3.1 Who develops the Test Project / modules

The Test Project / modules are developed by an Expert.

3.3.2 How and where is the Test Project / modules developed
The Test Project / modules are developed independently.

3.3.3 When is the Test Project developed
The Test Project/modules are developed before the previous Competition.

All Experts may bring a Test Project proposal (which must conform to the requirements set out in clause 2.2) for the next Competition. These Test Project proposals are displayed on the last day of the Competition and each Expert may give a short presentation on the design features of the Test Project. Only projects that conform to clause 3.3 will be eligible for voting.

3.4 Test Project marking scheme
Each Test Project must be accompanied by a marking scheme proposal based on the assessment criteria defined in Section 5.

3.4.1 The marking scheme proposal is developed by the person(s) developing the Test Project. The detailed and final marking scheme is developed and agreed by all Experts at the Competition.

3.4.2 Marking schemes will be entered into the CIS prior to the Competition.

3.5 Test Project validation
It must be demonstrated that the Test Project/modules can be completed within the material, equipment, knowledge and time constraints by a photograph being submitted with the Test Project proposal.

3.6 Test Project selection
The Test Project is selected by vote of all Experts at the previous Competition.

The Chief Expert organises a ballot of all the Experts present to select the Test Project for the next Competition. Each Expert may cast one vote. The Test Project that receives the most votes will be the one to be undertaken at the next Competition.

3.7 Test Project circulation
The Test Project is circulated via WorldSkills International website 3 months prior to the current Competition.

3.8 Test Project coordination (preparation for Competition)
Coordination of the Test Project will be undertaken by the Experts.

3.9 Test Project change at the Competition
The Experts will decide together on the 30% change at the Competition and will take into consideration the material available in the workshop, before deciding on the final Test Project design.

Each Expert may bring examples (drawings/photographs) of a 30% change which he has designed and carried out in his/her own country, as proof of its suitability to the overall Test Project. All of the examples of 30% change submitted by the Experts will be considered. A decision will be made on the final Test Project design by all of the Experts in consultation with the Workshop Supervisor.

3.10 Material or manufacturer specifications
- Copper pipe supplied by the Host Member must be of a grade that permits bending by hand operated machines. A data sheet for the copper pipe from the Host Member and details of the supplier/merchant must be made available to all participating Members 6 months prior to the Competition on the Infrastructure List and the Discussion Forum.

4. SKILL MANAGEMENT AND COMMUNICATION

4.1 Discussion Forum

Prior to the Competition, all discussion, communication, collaboration and decision making regarding the skill must take place on the skill-specific Discussion Forum (http://www.worldskills.org/forums). All skill-related decisions and communication are only valid if they take place on the forum. The Chief Expert (or an Expert nominated by the Chief Expert) will be moderator for this forum. Refer to Competition Rules for the timeline of communication and competition development requirements.

4.2 Competitor information

All information for registered Competitors is available from the Competitor Centre (http://www.worldskills.org/competitorcentre).

This information includes:

- Competition Rules
- Technical Descriptions
- Test Projects
- Other Competition-related information

Any materials-related requirements or manufacturers specifications shall be provided to the Competitor at the same time as the Test Project.

4.3 Test Projects

Circulated Test Projects will be available from worldskills.org (http://www.worldskills.org/testprojects) and the Competitor Centre (http://www.worldskills.org/competitorcentre).

4.4 Day-to-day management

The day-to-day management is defined in the Skill Management Plan that is created by the Skill Management Team led by the Chief Expert. The Skill Management Team comprises the Jury President, Chief Expert and Deputy Chief Expert. The Skill Management Plan is progressively developed in the six months prior to the Competition and finalised at the Competition (agreed by Experts and submitted to the Chair/Vice Chair of the Technical Committee). The Chief Expert is to regularly share updates of the Skill Management Plan via the Forum.

5. ASSESSMENT

This section describes how the Experts will assess the Test Project / modules. It also specifies the assessment specifications and procedures and requirements for marking.

5.1 Assessment criteria

This section defines the assessment criteria and the number of marks (subjective and objective) awarded. The total number of marks for all assessment criteria must be 100.

Section	Criterion	Marks		
		Subjective (if applicable)	Objective	Total
A	Dimension		40	40
B	Pressure test		12	12
C	Joint quality		12	12
D	Bends and angles		8	8
E	Health & Safety		4	4
F	Plumb and level		12	12
G	Material usage		8	8
H	Completion – In allocated time and Module as per drawing		4	4
	Total =		100	100

5.2 Subjective marking

Not applicable.

5.3 Skill assessment specification

The Experts will decide together on the marking criteria, reference points and the dimensional tolerances on Objective Marking Forms. As agreed by the Plumbing and Heating Experts there is to be a minimum of 100 and a maximum of 200 aspects of criterion.

Competitors will be given all the necessary materials prior to the commencement of each module. It is the responsibility of the Competitor with the compatriot Expert to check the material supplied against the module material list, which will have been previously checked and signed by the Workshop Supervisor and Workshop Supervisor's Assistant.

At the end of each day's work, the Competitor will be permitted five (5) minutes to re-check their measurements prior to the commencement of that day's marking outside the competition time.

Criteria for objective marking

Specific dimensional tolerances - ± 2mm and ± 4mm

- All remaining aspects will be marked with a YES or NO response.

Deductions from the total mark

Maximum deduction, 8 marks, carried out on final day C+4
One mark for each additional meter of pipe
One mark for each additional fitting or joint used

Dimensional tolerance for all linear dimensions

Dimension +/- 2 mm incl.	Full mark
Dimension +/- 4 mm incl.	Half mark
Above 4 mm	No mark

Dimensional tolerance for plumb, level and angles

0 +/- 1º	Full mark
Above 1º	No mark

If requested, competitors levelling equipment will be used during assessment

Joints

Examples of all joints to be circulated as photographs with the release of the Test Project 3 months before the Competition. All selected joints will be assessed using the criteria listed below (as minimum).

- Threaded joints on both BMS and GS to have all excess jointing material removed.
- Welded joints to be central over the joint and loaded (convex) / uniform pattern with no undercutting.
- Silver and soft-soldered joints to be fully loaded with no drips.
- All pipe fittings to be fitted as per manufacturer's instructions (that is, full dept of collar of fitting) for all modules.
- See Appendix 9.1 for a full description

Pressure test

- Directly after each successful pressure test, the two Experts who witnessed it must prove its validity by ensuring that the entire pipe-work installation was actually under test. Proving points provided at opposite ends of each pipework material Module, during the 30% change, would accommodate this.
- Competitors may pressure test their own work, as many times as they consider necessary, within the competition time.
- When the competitor reaches the stage in a Module when the two Experts are requested to witness the pressure test, this test will be considered the last and final test for this Module and this result will be the one recorded for assessment. The competitor will not be permitted under any circumstances to carry out further leak detection/repair work or request another pressure test for this Module.
- The entire witnessed pressure test must be completed within the competition time allocated to the Module for the result to be included in the competitor's assessment total.
- Effluent pipes will be air tested to 20kPa (0.2 bar) for 2 minutes.
- Hot water, cold water, gas and heating pipes will be air tested to 200KPa (2 bar) for 2 minutes
- The pressure gauge used for pressure testing gas, water and heating pipes to have a full scale deflection of 2 bar.

Pressure test marking

No drop in pressure gauge reading during test period	Full mark
Drop in pressure gauge reading during test period	No mark

- A removable clipboard must be provided at each workstation, in order to record the Competitors' pressure test results, safety warnings, extra material and the material list check

5.4 Skill assessment procedures

- Each module will be assessed in the evening of the day in which it was carried out.
- The Experts will be divided into teams of THREE by the Chief Expert, as outlined in the Skill Management Plan, to carry out the assessment each evening.
- The Chief Expert will ensure (within reason) that an equal number of assessment criteria and marks are allocated to each Expert marking group.
- All measuring instruments e.g. rules, protractors, levels etc. required for the assessment of the modules will be provided by the Host Member and will be new and used solely by the Experts for this task. If templates are required, these will be prepared by an Expert nominated by the Chief Expert and checked by all of the Experts prior to their use.
- All pressure tests must be witnessed and signed off by two experts and the result entered on the competitor's clipboard. This duty will be rotated daily among the Experts, by the Chief Expert, as outlined in the Skill Management Plan.
- Two Experts will be assigned daily to check that all Health and Safety regulations are observed by the Competitors. A record of each Competitor's safety warnings will be entered on his/her clipboard. This duty will be rotated among the Experts on a daily basis, by the Chief Expert, as outlined in the Skill Management Plan.
- Verification of each Competitors material check list and the recording, on the clipboard, of any extra material requested by a Competitor will be carried out by two Experts, who will be assigned to this task on a daily basis. This duty will be rotated among the Experts on a daily basis, by the Chief Expert, as outlined in the Skill Management Plan.

6. SKILL-SPECIFIC SAFETY REQUIREMENTS

Refer to Host Country Health & Safety documentation for Host Country regulations.

- A first-aid kit must be available throughout the Competition.
- Each Competitor MUST be equipped with the appropriate personal safety equipment as required by the Host Country's safety standards. As a minimum clear safety glasses and steel toe capped safety shoes must be worn during the Competition and familiarisation.
- All Competitors must use clear safety glasses and steel toe capped safety shoes at all times.
- Full heat-resistant gloves must be worn by Competitors when performing all hot work that is, heat bending of mild steel pipe, welding, hard and soft soldering.
- Long sleeve apparel must be worn when carrying out any work involving heat.

7. MATERIALS & EQUIPMENT

7.1 Infrastructure List

The Infrastructure List lists all equipment, materials and facilities provided by the Host Country.

The Infrastructure List is online (http://www.worldskills.org/infrastructure/).

The Infrastructure List specifies the items & quantities requested by the Experts for the next Competition. The Host Country will progressively update the Infrastructure List specifying the actual quantity, type, brand/model of the items. Host Country supplied items are shown in a separate column.

At each Competition, the Experts must review and update the Infrastructure List in preparation for the next Competition. Experts must advise the Technical Director of any increases in space and/or equipment.

At each Competition, the Technical Observer must audit the Infrastructure List that was used at that Competition.

The Infrastructure List does not include items that Competitors and/or Experts are required to bring and items that Competitors are not allowed to bring – they are specified below.

7.2 Materials, equipment and tools supplied by Competitors in their toolbox

Each Competitor is allowed toolboxes up to a maximum capacity of 500-litres approx. Competitors who bring larger tool boxes/chests to the Competition will not be permitted to keep them in the work area and they must be stored in an off-site location. When this occurs Competitors will be permitted to take with them into the work area the equivalent of 500 litres of hand tools from the oversized tool boxes/chests in one trip, using an appropriate container provided by the Host Country. All battery-operated hand tools/chargers brought to the competition, by the competitor, must be capable of being accommodated within the 500-litre approx. tool box/chest.

Hand tools of the trade required to complete the Test Project. The following minimum list of tools is provided for guidance only.

Tool	Qty	Tool	Qty
600mm rule	1	Safety glasses	1
300mm rule	2	Wire brush	1
500mm engineers square	1	Assorted files - (½ round and flat)	4
250mm square	1	Pipe de-burrer	1
150mm square	1	Set felt tip pens	1
1.5m rule	1	Permanent markers	4
1m rule	1	250mm 360' protractor	1
1.2m level Digital	1	250mm 60/30 set square	1
Metal Adjustable square	1	250mm 45 set square	1
200mm dividers	1	Adjustable set square	1
Scriber	1	Centre punch	3
600mm level - Digital	1	Spare tube cutting wheels	4
Magnetic torpedo level	1	Driver bits	4
Hacksaw	1	18 & 24 TPI hacksaw blades	4
Wiss snips L & R	2	Alloy soft jaws	2
300mm Shifter	1	Small magnetic holder for welding	1
250mm Shifter	1	Conduit Cutter for PEX pipe	1
200mm Shifter	1	Assorted screwdrivers	5
300mm multigrips	1	Flint gun	1
250mm multigrips	1	Welding goggles	1
100mm tube cutter (cu and pvc)	1	Leather gauntless	1
66mm tube cutter (cu and pvc)	1	All other to be supplied by Competition organisers	
42mm tube cutter (cu and pvc)	1		
Midget tube cutter	1		
450gm ball pain hammer or claw hammer	1		
5m tape measure	1		
Stanley knife and blades	1		
14" stillson	1		
10" stillson	1		

Note: All other tools will be supplied by the Host Country.
See the Infrastructure List - http://www.worldskills.org/infrastructure/.

Safety equipment: See Section 6, Skill-specific safety requirements.

7.3 Materials, equipment and tools supplied by Experts

Not applicable.

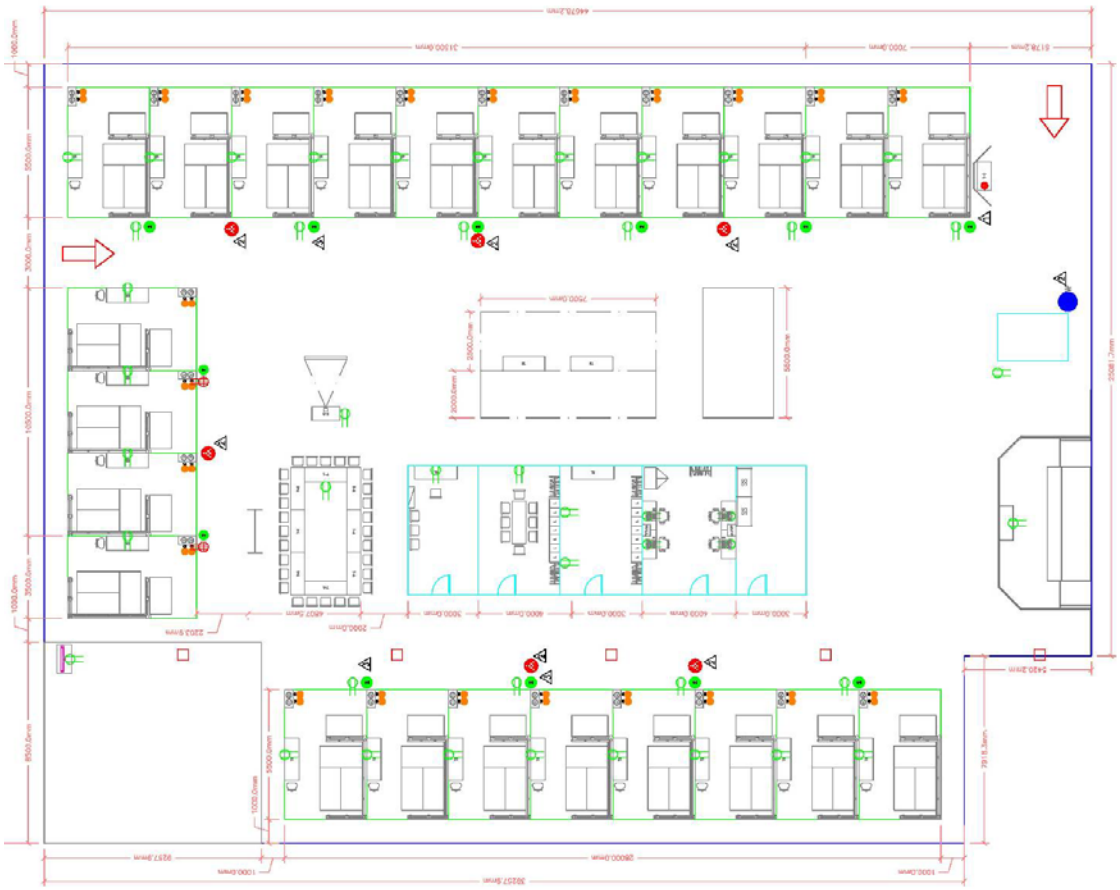
7.4 Materials & equipment PROHIBITED in the skill area

- Pre-made templates or jointing materials are prohibited.
- Mains electric powered equipment other than rechargeable battery-operated hand tools.
- Competitor's own pre-made templates, jointing material, fluxes and welding/soldering consumables are prohibited in the skill area.
- Note: the use of solvent welded joints on PVC pipe and cupro-eutectic joints on copper pipe are not permitted.

7.5 Sample workshop layouts

Workshop layouts from Calgary are available at:
http://www.worldskills.org/index.php?option=com_halls&Itemid=540

Workshop layout:



8. MARKETING THE SKILL TO VISITORS AND MEDIA

8.1 Maximising visitor and media engagement

- A full colour copy of the project drawing (without dimensions) should be prepared for displaying to the public, for information, at the skill area.
- A live timed water test may be carried out by Competitors, possibly 3 at a time with an explanation via load speaker to visitors and media to maximise engagement.
- A 4 hour team challenge could comprise of two identical renewable energy/green technology projects, which each team of competitors would be required to erect, assemble and test in the allocated time. In relation to the projects. The task could be either a Grey Water Recycling System or a Passive Solar Hot Water System.

Other ways to maximise engagement may include:

- Try a skill – for example the bending of copper pipe
- Display screens
- Enhanced understanding of Competitor activity
- Competitor profiles
- Career opportunities
- Daily reporting of competition status

8.2 Sustainability

Project design and Competition preparation will consider the following:

- Recycling of materials and water where used
- Use of 'green' materials where possible
- Use of completed Test Projects or components of the Test Projects after the Competition

9. APPENDICES

9.1 Assessment criteria for joint quality

A concise explanation of the assessment criteria for joint quality is currently been developed and will be made available on the Discussion Forum 12 months prior to the Competition.