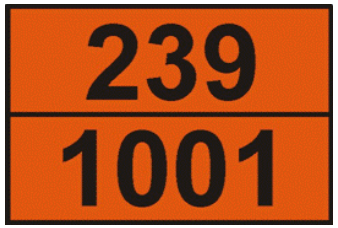
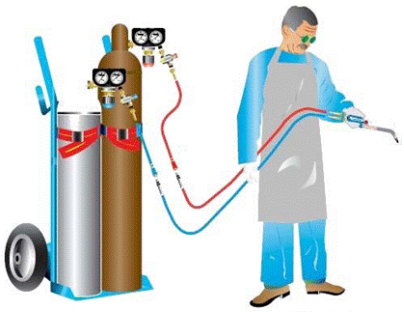
ACETYLENE GAS SAFETY SEMINAR 2010
MALAYSIA





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Safety Features Of Acetylene Cylinders and Bundles

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Air Products

Physical Properties of Acetylene

Chemical formula	C2H2
Specific mass (0 degC, 1.013bar)	1.172 kg/m^3
Relative mass (Air = 1)	0.908
Critical temperature	35.2 degC
Critical pressure	61.9 bar
Heat of formation $\Delta Heat_f$ (25 degC, 1.013 bar)	227.4 kJ/mol
Heat of combustion $\Delta Heat_c$ (25 degC, 1.013 bar)	1,301.1 kJ/mol
Flammability limits (in air)	2.3 – 82 %vol
Flammability limits (in oxygen)	2.5 – 93 % vol
Auto ignition temperature in air	305 degC
Auto ignition temperature in oxygen	296 degC

Why is Acetylene Different to Other Industrial Gases?

Acetylene can decompose
in the absence of oxygen or air

$$C_2H_2 \rightarrow 2\ C + H_2$$

$$\Delta\ Heat = -227\ kJ/mol$$

A LOT OF HEAT!

= -8733 kJ/kg (≈ 1.9 TNT-equivalents)

Storing Acetylene in Gas Cylinders

- Storage of acetylene in cylinders requires special precautions in order to prevent explosive decomposition of the acetylene within the cylinder
- There are standards for acetylene cylinders and valves which require specific tests to ensure the cylinders and valves are safe

How is Acetylene Stored in Cylinders?

- The cylinder is completely filled with a porous material which may be either:
  - a monolithic block consisting of calcium silicate hydrate with a porosity of about 90 %

  or

  - a granular or charcoal material
- The porous material absorbs a solvent (usually acetone) so that the solvent is evenly distributed in the cylinder

How is Acetylene Stored in Cylinders?

- Acetylene is dissolved in the solvent – “Dissolved Acetylene” or “DA”
  - Note Special Applications Solvent Free Acetylene UN 3374
- The porous material not only hold the solvent but must be able to stop an acetylene decomposition
- As well the cylinder valve needs to be able to resist decomposition in the cylinder

Inside of Acetylene Cylinders

Monolithic

Non Monolithic

Acetylene Cylinder by Weight

- Modern Monolithic Porous Material typically has a “porosity” of 92%
- Or in other words only about 8% is “solid”:
- Typical 40 litre C_2H_2 cylinder will weigh about 60 kg of which:
  - Solvent: 19 kg
  - Shell: 30 Kg
  - Mass :5kg
  - Acetylene 6 kg

- Tare weight = Cylinder + Mass + Valve + Solvent

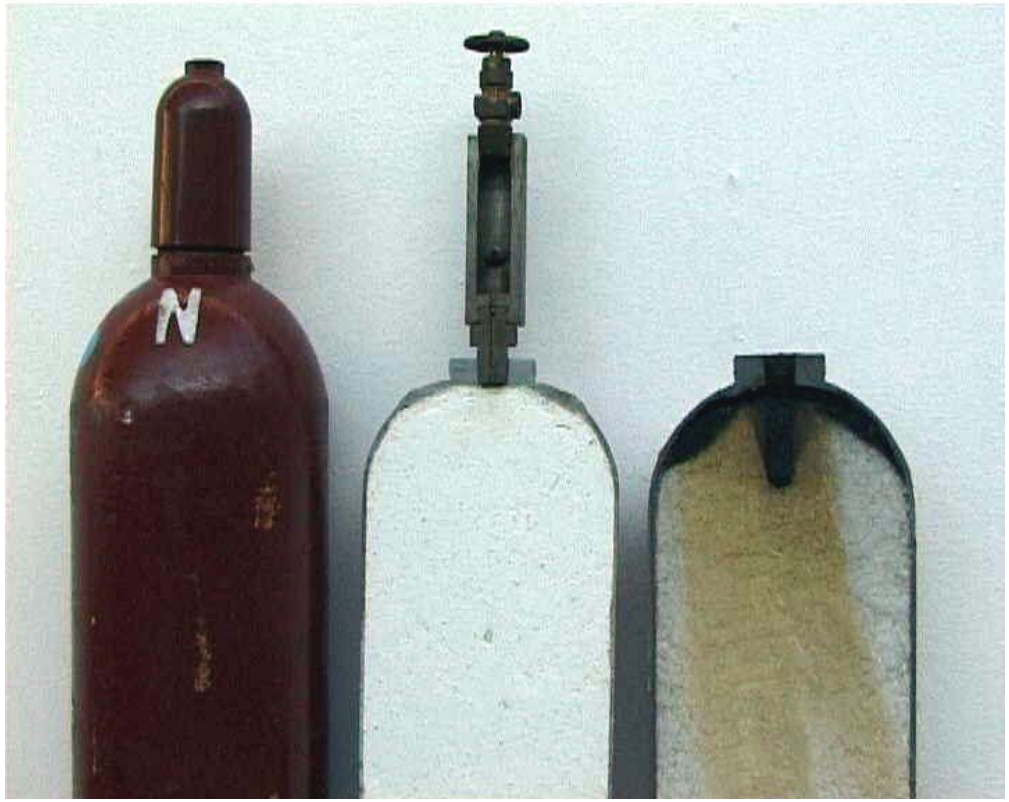
Approval Tests for Acetylene Cylinders

- Acetylene Cylinders must be made to the applicable standards for the country of use
- Where there are no National Standards consider using ISO 3807 Cylinders for acetylene basic requirements
- ISO 3807-1 without fusible plugs
- ISO3807-2 with fusible plugs

Example of Approval Tests for New Designs of Acetylene Cylinders

- Testing of the cylinder shell
  - Standards for welded (or seamless cylinders)
- Additional testing of the acetylene cylinder after it is filled with porous material
  - Elevated temperature test to ensure that no hydraulic pressure will be generated
  - Backfire test to ensure that the porous material is able to stop an acetylene decomposition in the cylinder

Cross Section of Acetylene Cylinder After Passing the Backfire Test



- Cylinder is
  - overfilled (+5%)
  - heated (35 ° C)
- Start of acetylene decomposition
  - by melting a metal wire in the ignition tube

Cylinders After a Backfire on a Filling Plant

Failure of Acetylene Cylinders

- A decomposition in an acetylene cylinder might be started by a backfire or a fire or intense heat
- If the porous material does not stop the decomposition, the cylinder will burst after several hours (or even after a day)
- Failure of an acetylene cylinder can result from any free volume in the porous material e.g. caused by
  - ✔ too large a gap
  - ✔ cracks
  - ✔ loose porous material
- Such cavities might act as a location where the acetylene decomposition is not stopped and constantly supplied with acetylene

Approval of the Porous Material

- The approval shall define requirements for safe usage
- Requirements for safe usage include information regarding
  - Size and type of cylinder shells
    - e.g. seamless or welded cylinders
joggle or butt welds
  - Density and porosity of the porous material
  - Core hole filters
  - Maximum permissible top clearance
    - top clearance has to be tested
  - Permissible solvent content
  - Maximum permissible acetylene content

Quality Control for the Porous Material

- The porous material, particularly monolithic material is very sensitive to changes in the production process
  - Its integrity must be ensured by an effective production quality assurance that includes:
  - Raw materials
    - Specifications and inwards inspection
  - Control of porous material to be filled in the cylinders
  - Control of autoclaving process
    - Temperature and time
  - Gap measurement
  - Porosity determination

Porous Material

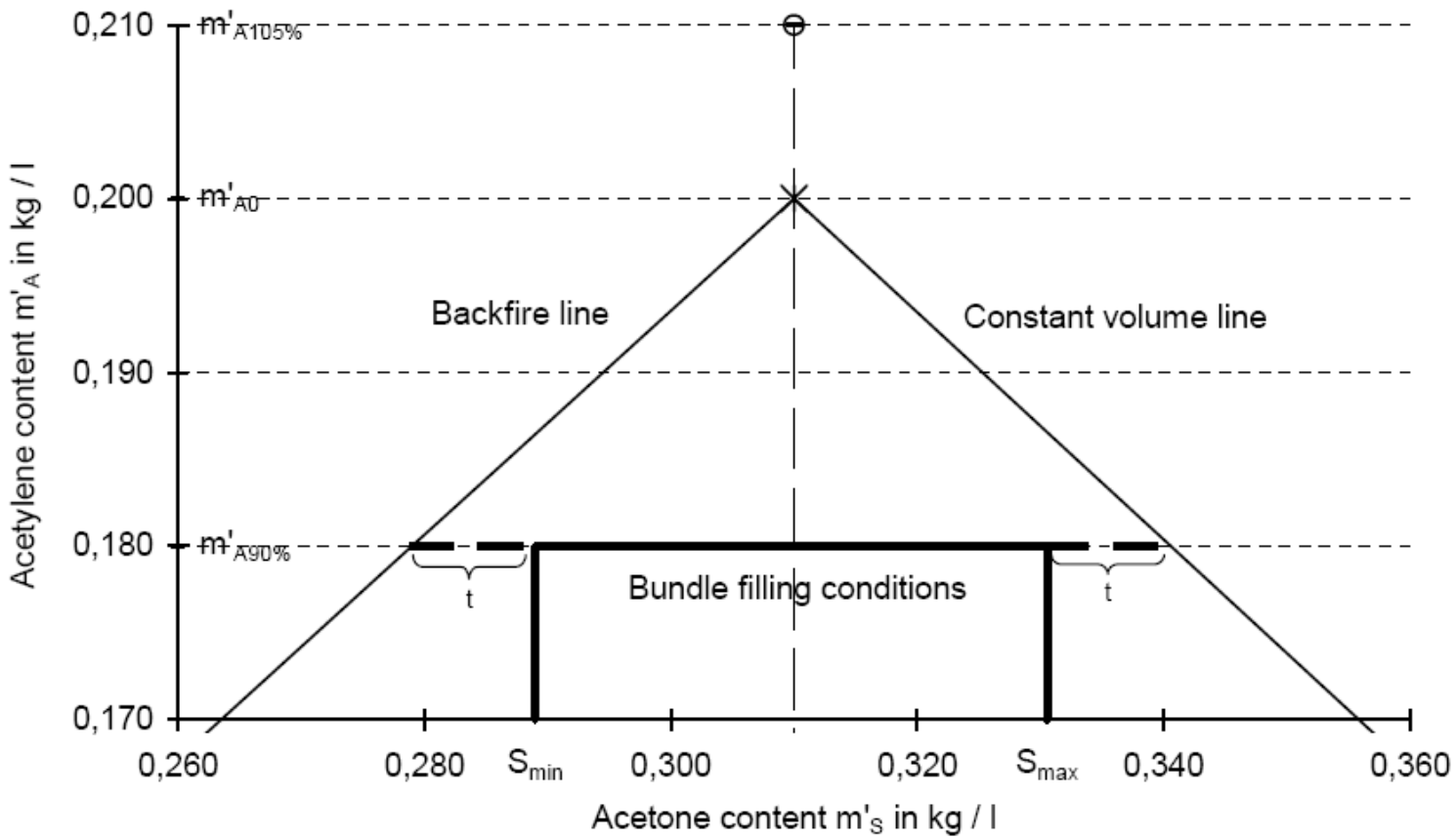
- Different types of porous materials have different requirements for safe usage
- These may be different in different countries even for one single type of porous material

Acetylene Filled in Bundles

Acetylene may be filled in bundles

- Specific precautions required if filled as a complete unit
- Construction requirements and flash back arrestors
- Acetylene content reduced and filling cycles reduced between solvent checks
- See European Standards EN 1800, EN 12755

Determination of Filling Conditions of Acetylene Cylinders and Bundles



Fusible Plugs

- Major difference between Europe and many other parts of the World – Fusible Plugs
- Europe does not use them, many other parts of the world do use them
- Technical arguments both for and against their use. No harmonised view yet
- Follow the requirements of the regulations of the country of use

Acetylene Cylinder Valves

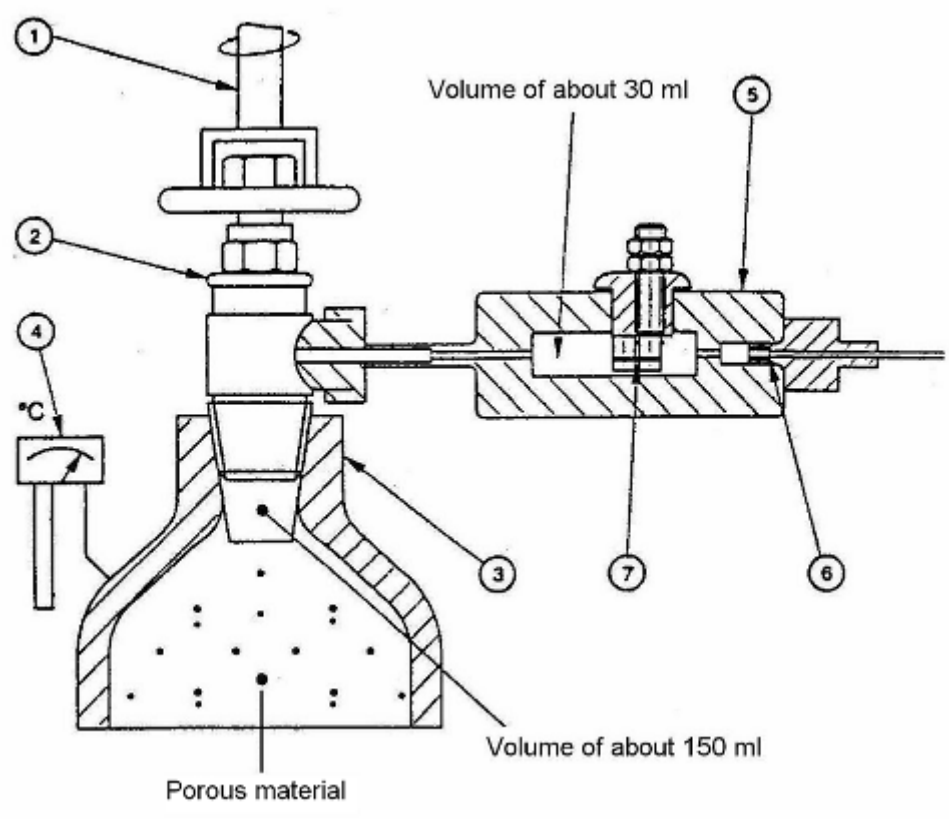
- Cylinder valve is very important – it is the customer interface and keeps the gas in the cylinder!
- Must conform to a standard,
  - Examples ISO 10297
- Tests for the valve and additional test because it is an acetylene valve
- Material requirements for acetylene cylinder valves, copper content below 65%,silver content below 43%

Type Tests of a Cylinder Valve

- Testing of cylinder valves can include, depending on the standard:
  - Hydraulic pressure test
  - Tightness tests (different pressures/temperatures)
  - Endurance test
  - Excessive torque test
  - Flame impingement test
  - Impact test (if no valve protection is used)
  - Additional tests for acetylene cylinder valves

Acetylene Flashback Test

- According to ISO 10297



1 Remotely operated closing device

2 Test sample valve

3 Acetylene cylinder

4 Temperature indicator

5 Igniter tube

6 Bursting disc

7 Constantan wire

Acetylene Cylinders and Valves - Summary

- An acetylene cylinder that is in compliance with all the requirements of the standards in normal conditions should provide a long term reliable service, considering that it is inspected and maintained periodically
- Acetylene valves are important, not only do they keep the gas in the cylinder, it is the item the customer uses the most!

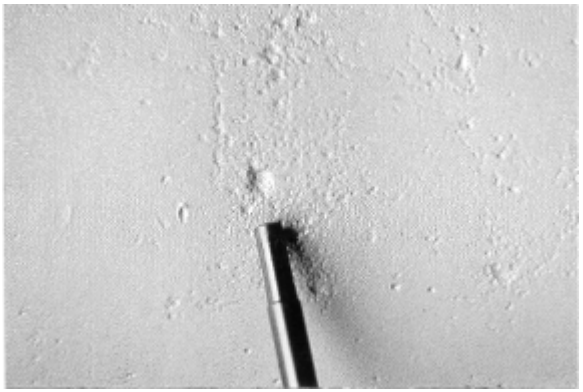
Periodic Inspection and Requalification of Acetylene Cylinders

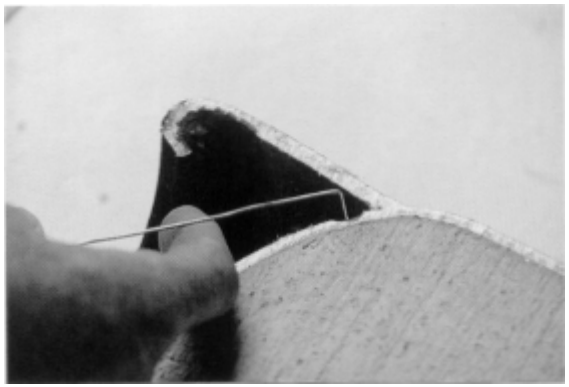
- Acetylene Cylinders require to undergo a periodic examination to ensure that they are “fit” for continued use
- Intervals between inspections vary according to regulations, (e.g. between two to ten years)
- Examples of standards to follow:
  - ISO 10462 Gas cylinders -- Transportable cylinders for dissolved acetylene -- Periodic inspection and maintenance
  - CGA C-13 Guidelines for Periodic Visual Inspection and Requalification of Acetylene Cylinders

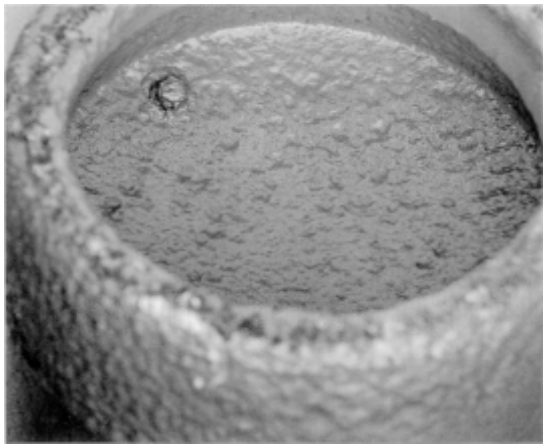
Periodic Examination of Acetylene Cylinders

- Two components to the Periodic Examination
  - Cylinder shell, (the outside) and the cylinder valve
  - Porous Material (the inside)
- Cylinder Shells
  - Most cylinder shells are welded, though seamless are used
  - Need to look for damage such as dents and corrosion
- Porous Material
  - Either “granular” (charcoal) non monolithic mass or
  - Monolithic mass

Cylinder Shell Examination



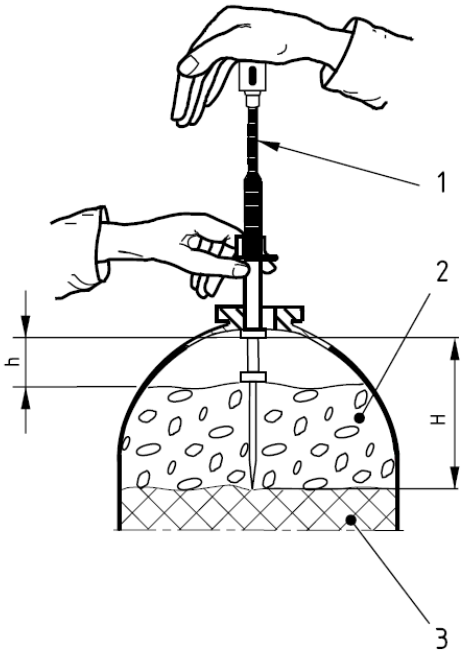


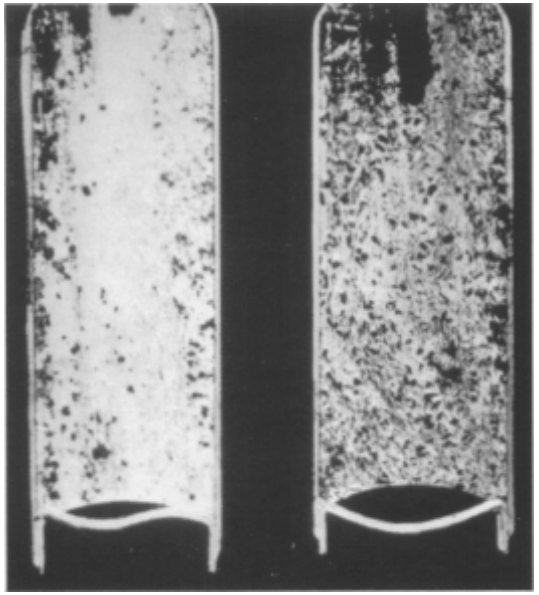


Examples from CGA C-13

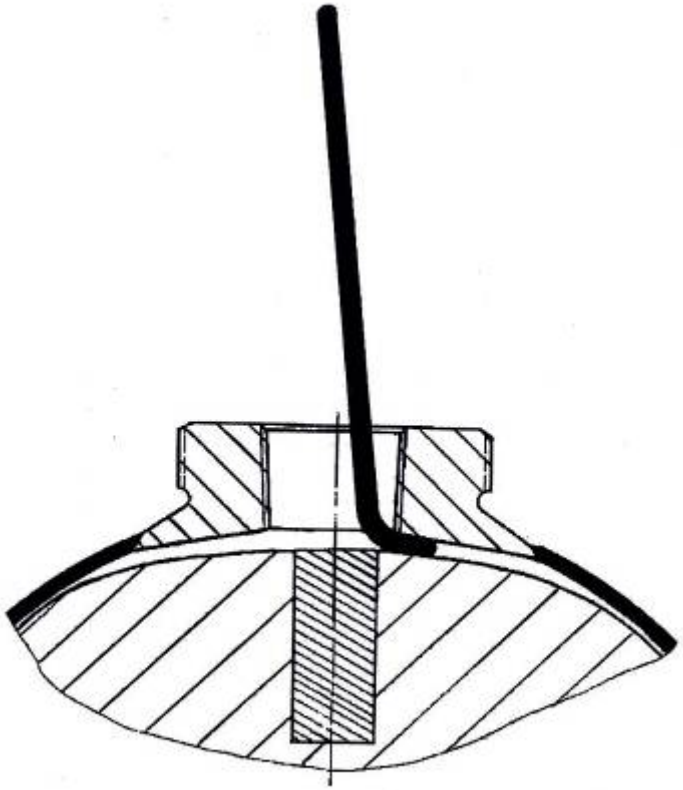
Examination of the Porous Material

- Examination technique depends upon the type of Porous Material
- Granular
  - Compaction
  - Cavities
- Monolithic
  - Cracks
  - Crumbling
  - Cavities





Example of Top Clearance



Examples of Porous Material Defects

a) Hairline crack without visible sidewalls

b) Crack with visible sidewalls

Periodic Inspection Summary

- Some important points to note:
  - Cylinder Inspection should only be carried out in areas specifically designated and designed for inspection
  - Personnel shall be trained in all aspects of inspection
  - Written procedures
  - Recovery and venting of acetylene prior to valve removal
  - Limit number of cylinders with the valve removed
  - Don’t forget the valve!
  - See EIGA Doc 79, Cylinder Retest Stations

Materials of Construction for Bundles Manifold

- Steel is the preferred material for the construction of acetylene system components

Material	Conditions for use
Copper and copper alloys containing more than 70% copper	Not allowed
Alloys containing up to 70% Copper	Permitted. Special consideration should be given to the use of copper alloys for filters, sieves etc. that have a large surface area in contact with acetylene and also for parts in contact with moist unpurified acetylene. Any heat process which produces copper enrichment on the surface of the copper alloy shall be avoided.
Silver and mercury	Not allowed

Materials of Construction for Bundles Manifold

Silver alloys	Suitable for brazing, provided that the silver content does not exceed 43%, the copper content does not exceed 21% and the gap between the two parts to be brazed does not exceed 0,3 mm. Special care shall be taken to minimise the area of filler metal exposed to acetylene and to remove as far as is practicable all traces of flux.
Aluminium, Zinc Magnesium, and their alloys	Not recommended for components, which come in contact with **wet acetylene** contaminated with lime or ammonia (un-purified generator gas).
Zinc	Suitable as anti-corrosion protective coating

Acetylene Bundles Safety Consideration

- Review design requirements
  - Provision for lifting and moving
  - Resistance to dropping
  - Gas manifold design
  - Cylinder retention and resistance to twisting
  - Corrosion of cylinders and frames
  - Use correct material of construction

Acetylene Bundles Safety Consideration

- During transportation
  - Proper designed trucks
  - Secure cylinder and bundles
  - Even load distribution

Consequences Are Severe!

Thank You!

Acknowledgement:
Presentation was adapted from materials prepared by Andy Webb for the Acetylene Seminars in Asia