

Risk management and safety rules for the high pressure facilities of the GPD μ SR spectrometer in the experimental hall (WEHA)

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Date: 27 May 2019

Version: 1

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Date: 12. 6. 2019

Signature:



1 General description of the pressure facility and its applications

At the Swiss Muon Source (μS) of the Paul Scherrer Institute (PSI) material science is performed by investigating diverse materials using the local probe technique muons spin rotation/relaxation or resonance (μSR). The specimens (or samples) are investigated under the influence of external parameters like temperature, magnetic field or hydrostatic pressures. For the latter the Laboratory for Muon Spin Spectroscopy (LMU, NUM Division) develops pressure cells and uses them for in-house research and in the realm of the μS user facility at the μSR instrument GPD which is installed at the μE1 experimental area. The pressure cells are loaded and pressurized in the room Studio D in the experimental hall (WEHA). In the same room the pressure is determined by ACS measurements in a helium bath cryostat at low temperatures. The loaded cells are then transported to the experimental area μE1 where the cells are attached to a sample stick which is transferred into the cryostat for the actual μSR measurement. After the μSR experiment, the pressure cell is detached from the sample stick and brought into Studio D for changing the applied pressure or for unloading the cell.

2 General safety rules

The handling of pressure cells is only allowed for trained persons.

The handling of the pressure cells has to be done according to safety rules defined in this document and the technical manual (<https://www.psi.ch/en/smus/gpd>).

For pressurizing the cells only a suitable and safe hydraulic presses shall be used. A suitable and certified hydraulic press (TM-A1006) is available in Studio D. The hydraulic press has to be operated within its specification and according to its operation manual (<https://www.psi.ch/en/smus/gpd>).

General safety rules are reported on a safety sheet displayed at Studio D and the μE1 area (see attached photographs). This safety sheet is attached as an Appendix to the present document.

The removal of safety measures is strictly forbidden as well as working without the technical safety measures described in this document.

All type of pressure cells are tested up to the so-called yield pressure after fabrication. User normal operation is only allowed up to 80% of this pressure. This limit of 80% is called “maximum pressure” or “maximum operation pressure” in the following.

3 Guideline for a safe choice of pressure cell materials and components

Most of the experiments are performed by using a double-wall pressure cell with the outer cylinder made out of MP35N alloy. This alloy is characterized by an extended non-elastic region (~200% in the stress-strain diagram). This also prevents the extension to the outside area of any kind of damage possibly occurring inside the pressure cell. In other words, the outer cylinder made out of MP35N alloy,

can be considered as a first security stage preventing the pressure cell failure (see also attached figure of the pressure cell below).

All fixation materials as the top and the bottom of the pressure cell like fixation bolts, locking pads, sealing elements must be checked visually before being used with the cell. In a case of any visible damage like cracks, rounded thread, etc. the corresponding element needs to be replaced with a perfectly functioning one. The discarded element should immediately be disposed to prevent further use.

All fixation elements should smoothly enter the cell without any detectable friction. The elements which do not fit inside the cell, or enter the cell with a sizeable friction need to be replaced and disposed.

4 Personal safety equipment

The personal safety equipment is stored in Studio D and includes (see the attached figures):

- Kevlar gloves,
- Face protecting helmets,
- Protective jackets.

This equipment has to be worn at all times when handling the loaded pressure cells.

5 Risk identification and risk minimization

In the following section various risks are identified and technical and/or administrative means to minimize the risk to a tolerable level are described.

5.1 Risk/dangerous situation: Loading the pressure cell and activities in Studio D

- Risk:** Squashing limbs/digits under the press
- Administrative action:** Rule to only place/remove cells into press when the oil pressure in the hydrostatic cylinder is zero (i.e. when the pressing pad is not touch with the cell). Only handle pressure cell if there is at least a 1 cm gap between the press and the pressure cell.
- Technical action:** Hard limit for the maximum pressure of the press set to 260 bar (~11 tons).
-
- Risk:** Explosion of the cell while applying pressure
- Administrative action:** Follow loading rules described in the technical manual (<https://www.psi.ch/smug/gpd>)
- Technical actions:** The solid angle around the cell is protected by plexiglass/steel in the directions that could be harmful.
-
- Risk:** Exposing the hands during the tightening of the cell (due to large solid angle).
- Administrative action:** Only put the hand into the press region to tighten the pressure cell.
- Technical action:** After the change of pressure in the cell, wait at least 10 minutes before entering hands to the press region to handle the cell. Use protective gloves.
-
- Risk:** Overdriving the press
- Administrative action:** Rule to be always present and concentrated upon application of pressure.
- Technical action:** The pressure limiter is mechanically set to 260 bar (~11 tons).
-
- Risk:** Explosion of the cell after application of pressure
- Administrative action:** Rule to leave the cell for 10 minutes after pressure application and 30 minutes if pressure is above 75% of the maximum pressure value.
- Technical action:** Use the protective cylinder for as long as possible and then move the cell immediately to the protection ammo-box.

Risk: Accidents upon mounting the cell to the ACS measurement stick.
Administrative action: none
Technical action: Plexiglas and steel protection shield, protective gloves

Risk: Accidents upon moving the cell from the table to the ACS measurement cryostat.
Administrative action: For pressures above 75 % of the max pressure, use the protective cylinder.
Technical action: Protective steel cylinder, tighten the cylinder with all the screws.

Risk: Failure of the cryostat walls
Administrative action: Working according to PSI prescription AW-96-16-05
Technical action: The glass cryostat is protected by Plexiglas and Aluminium shields towards the user.

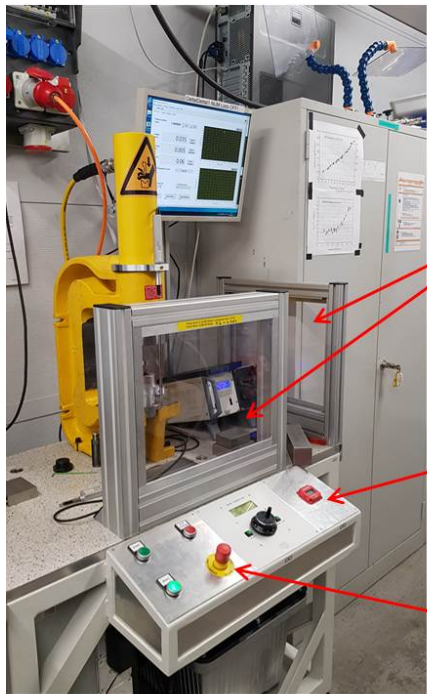
5.2 Risk/dangerous situation: Transportation of loaded pressure cells from Studio D to the μ E1 Experimental Area

Risk: Accidents upon transportation of the loaded pressure cell to the μ E1 area.
Administrative action: The pressure cell must be carried inside the protection ammo-box.
Technical action: Ammo-boxes (ammunition boxes) are available for the transport. The pressure cell must be carried inside the protection ammo-box.

5.3 Risk/dangerous situation: Mounting the pressure cell on the sample holder and placing it into cryostats

Risk: Accidents upon attaching the cell to the sample holder and placing/removing the cell from Heliox or Janis cryostats.
Administrative action: Only trained persons are allowed to mount the cell on the sample holders (Heliox, Janis). Only trained persons are allowed to place/remove the sample holder, with the pressure cell mounted on it, to/from the cryostats.
Technical action: The place where the pressure cell is removed from the protection ammo-box and further attached to the corresponding sample holder (Heliox, Janis) is covered by shields (transparent plastic glasses with metallic frames). Scientists must wear the personal safety equipment, see chapter 4.

6 Attachments (pictures and figures).



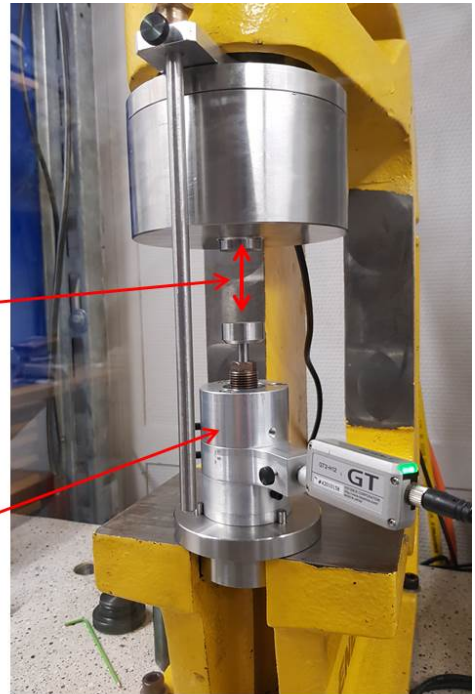
Protective glass
in metal frame

Gap between
the press and
the pressure cell

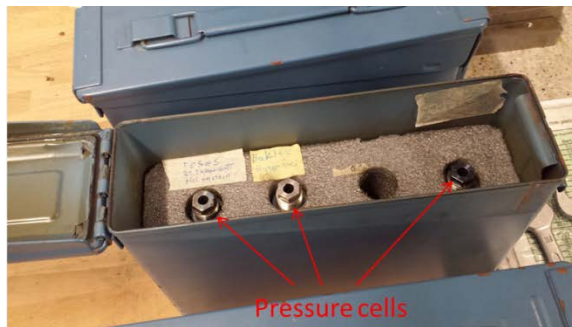
Pressure indicator

Protective cylinder

Emergency switch



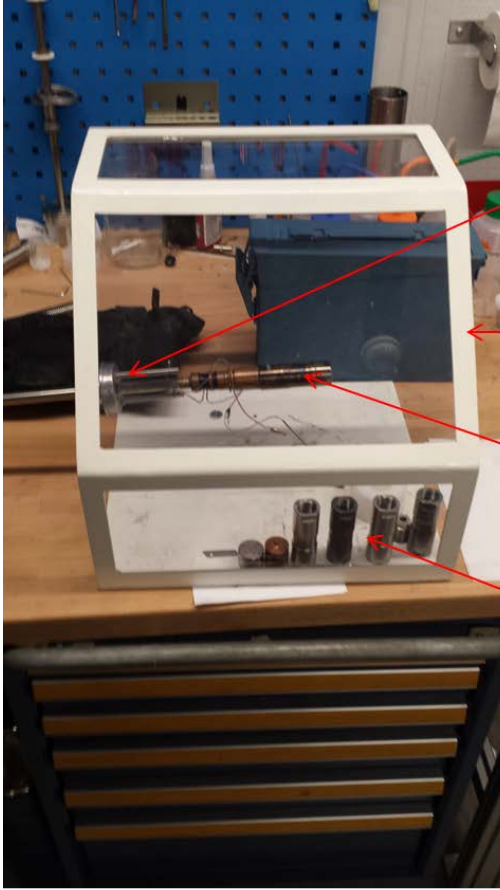
Computer controlled press with the Emergency switch, protective frame and metallic cylinder



Pressure cell carrying and storage ammo-boxes.



Protective Cylinder for ACS measurements



ACS sample stick

Protective glass

Mounted cell

Empty Pressure cells

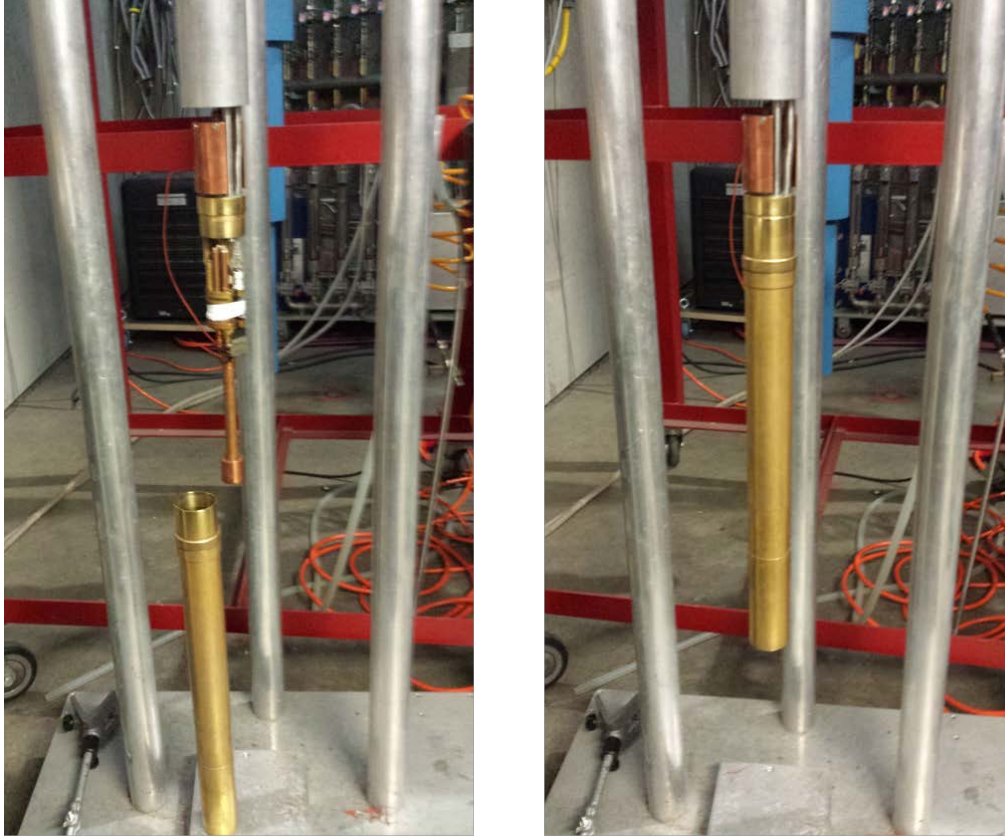
Pressure cell mounted to the ACS sample stick



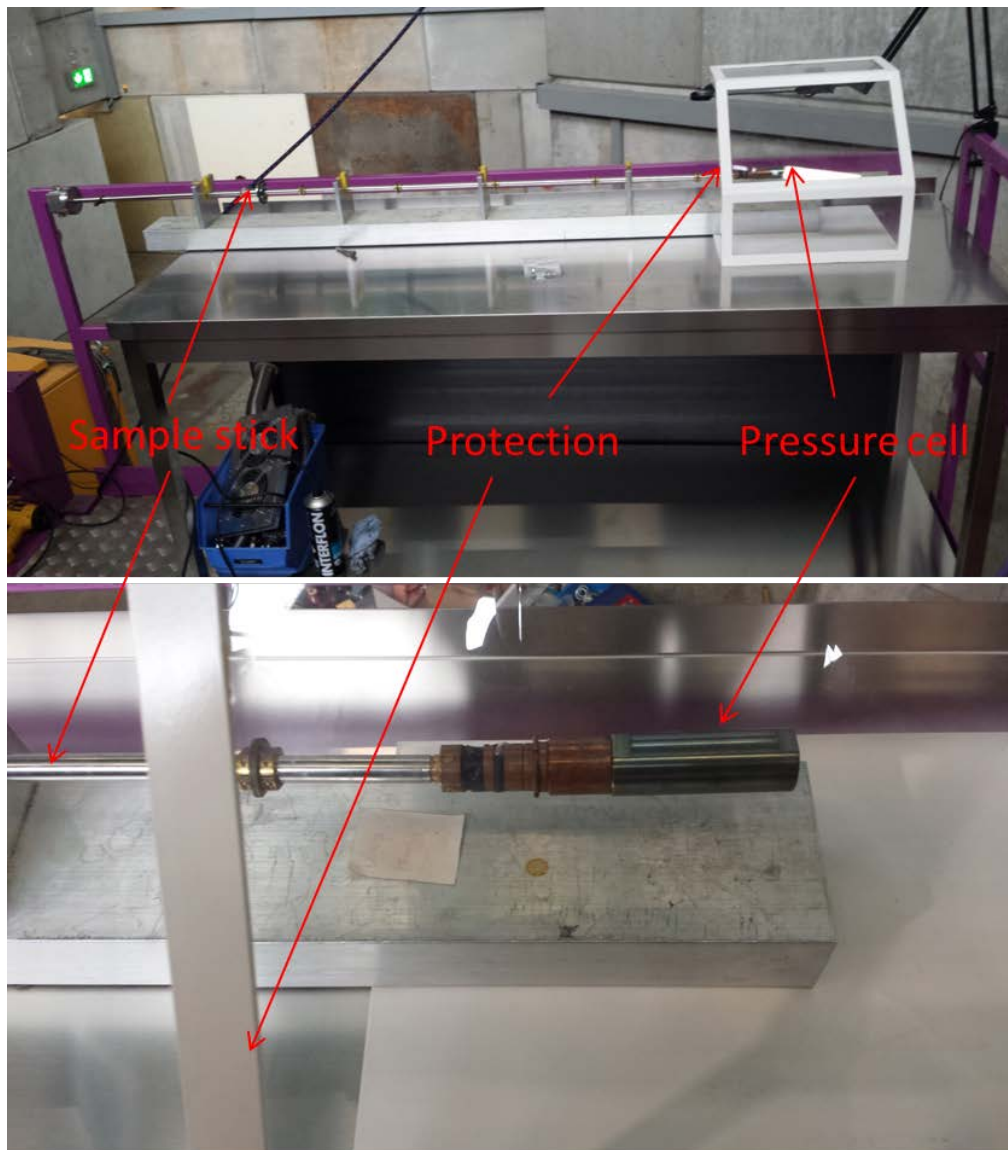
Protective Jackets, masks and
Kevlar gloves



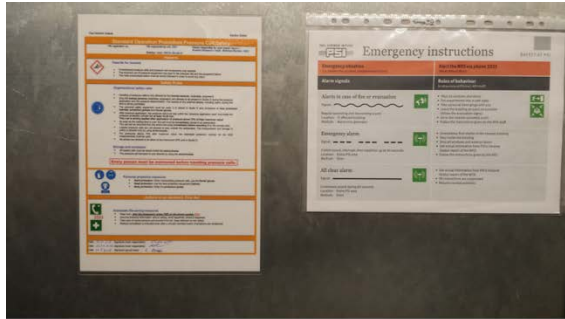
ACS glass cryostat with protective sheets



The end part of the Heliox inset. The pressure cell stays inside 1.5mm thick metallic cylinder (yellow cylinder)



Pressure cell mounted to the sample stick of Janis cryostat










Safety rules for pressure cell operation and various places in Studio A, Studio D and μ E1 area.



7 Appendix: Safety sheet

Paul Scherrer Institute

Section Safety

Standard Operation Procedure Pressure Cell Safety		
PSI registration no.:	PSI organizational unit: 3501	Person responsible for room (name / phone): Rustem Khasanov / 5438, Matthias Elender / 5423
Building / room: WEHA / Studio D		
Hazards		
	Hazards for humans <ul style="list-style-type: none"> Overstressed pressure cells and pressure cell components may explode The incorrect use of pressure equipment may lead to the pressure cell and the equipment failure The rules summarized below must be strictly followed in order to avoid any injury 	
Safety Rules		
	Organisational safety rules <ul style="list-style-type: none"> Handling of pressure cells is only allowed for the trained persons (scientists, engineers) Only the trained persons (scientists, engineers) are allowed to be present in Studio D during the pressure application and the pressure determination. The access of any external people, including users, during this time is strictly prohibited The personal safety equipment must be used. It is stored in Studio D and comprises of face protection helmets, protection jackets and Kevlar gloves. After pressure application, the pressure cell must stay within the "pressure application area" and inside the pressure protection cylinder for at least 15-20 min. This rule is strictly applied after application of pressure above 75% of their maximum value! As soon as the waiting-time is over, the cell must be immediately placed in an ammo-box. The cell can be removed from the ammo-box only immediately before mounting it on the sample stick. Loaded pressure cells are not allowed to stay outside the ammo-box. The transportation and storage of cell(s) is allowed only by using ammo-boxes. For pressures above 75% their maximum value, the dedicated protection cylinder for the ACS measurements must be used. No photos are allowed to be taken at the instrument GPD and in Studio D. Storage and workplace <ul style="list-style-type: none"> All loaded cells must be stored inside the ammo-boxes. The pressure cell transport is only allowed by using the ammo-boxes. 	
Every person must be instructed before handling pressure cells.		
  	Personal protective measures <ul style="list-style-type: none"> Hand protection: When manipulating pressure cells, use the Kevlar gloves. Head protection: Use the face protection equipment (helmet). Body protection: Wear the protection jacket. 	
Actions in an Accident, First Aid		
 3333 	Immediate life-saving measures <ul style="list-style-type: none"> Keep calm, alert the emergency center (SIZ) on the phone number 3333 Give the following information: who is calling, what happened, where it happened. Take care of injured persons and provide First Aid. Keep attention to own safety. Medical consultation is indicated even after a virtually harmless event, if symptoms are recognized. 	
Date:	Signature (room responsible):	
Date:	Signature (room responsible):	
Date:	Signature (group head):	