Advice on Processing using the SELFRAG Lab: Wear Parts and Materials

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Foreword

This document is initially intended to provide a guide on how to extend the life of wear parts, and give information on the pitfalls of processing certain materials. The list of materials is constructed primarily from personal experience of a range of SELFRAG staff during their time using the machine is by no means exhaustive: it simply reflects the materials (both geological and man-made) most likely to cause to impact the lifespan of wear parts. The intention is for this to be a ‘living document’ and updated over time as our clients and distributers come to us with their experience of new processing challenges to overcome. Likewise, if you have queries on any materials, please contact us on the following:

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1 Life expectancy of wear parts

The below life span estimates are based on the processing of correctly sized (fits between the electrodes/passes through a 40mm sieve) 'bulky' material such as rock, broken concrete, etc. that readily break down during processing. Frequent processing of oversized material will engage collision mode more often (consult lab manual) causing stress on the working electrode, counter electrode, and metal shell, reducing life span. Processing of material that does not readily break down means that electrical and kinetic energy generated by the discharge is absorbed by the process vessel and reduces lifespan.

1.1 Electrode

1.1.1 Working Electrode Tip

The standard 6 mm working electrode tip (WE) has a life span of around 150,000 discharges, and will gradually be worn down over time. The WE tip will gradually shorten over time, until it becomes more rounded. The round shape is poor for discharging, and the user will notice pulse to discharge ratio when processing will change. This is an indicator to replace the electrode tip. From winter 2016, SELFRAG will also stock 2, 4 and 8 mm WE tips, the 2 and 4 mm tips being for specific uses, and having a significantly shorter life expectancy. When reaching the end of its life (generally less than 5 mm extent left), the 'fingertip' of the WE will likely break off. Stop using it immediately as the electrical field will now be different, with increased likelihood of discharge into the PV liner, causing damage.

1.1.2 Counter Electrode (CE)

Counter electrode has a life time of around 150,000 discharges, and will gradually be worn down over time. Frequently check the integrity of the CE O-ring as material can be trapped beneath, causing wear. Eventually the CE will wear to a point that a 'ring' of oxidised metal will appear on the upper surface as the CE is worn through. This is an indicator to order a new CE as a change is due very soon.

1.1.3 Contact Lamellae

The contact lamellae are designed to grip the Process Vessel (PV), preventing rotations, and also ground the vessel. These are responsible for the small, regular lines/abrasions that can be seen on the outer metal shell of the PV.

With use, these will become dirty and they should be considered during general lab cleaning as material can become trapped between the lamellae, warping them. This can then cause damage to the process vessel. If these small abrasions become suddenly deeper, please inspect and change the contact lamellae. This is part of a normal lab service. Removing the lamellae will likely break their locating pins, especially when dirty, so please contact your local distributer for a replacement before servicing by the super user.

1.1.4 General Caveats

Frequently processing over-sized samples in 'collision mode' will abrade the WE and sharply shorten WE life expectancy. Frequent processing at high (180 – 200 kV) energies at low electrode gaps (10 mm) or where the WE is within 10 mm of the sample, is also thought to impact life span.

1.2 Process vessel metal shell (open)

The process vessel (PV) metal shell has a life expectancy of around 400,000 pulses based on batch processing of 50 – 100 pulses at 150 – 180 kV, however this is largely dependent on process conditions and sample material. The open PV has a square hole where the square peg of the CE slots in, preventing it from moving. Over time, this will become worn, and become a round hole, allowing the CE to rotate. When this occurs, the shell needs to be replaced.

1.3 Process vessel metal shell (closed)

The PV metal shell has a life expectancy of around 400,000 pulses based on batch processing of 50 – 100 pulses at 150 – 180 kV, however this is largely dependent on process conditions and sample materials. Over time and with use, cracks will begin to appear on the bottom plate of the closed vessel due to the large forces involved in treatment, and the PY will no longer be water tight, and should be replaced immediately.

1.4 Process Vessel Liner

The PV liner has a life expectancy of 150,000 pulses. Over time the liner will darken and get stained by processing materials. Occasionally discharges my hit the liner, and cause damage, which in turn attracts more discharges. More conductive materials such as pure metals (Section 0) or materials encased in metals (Section 4.2.1) conduct the electrical discharge away, and, if in contact with the vessel liner, the discharge can ground into the plastic, causing damage.

1.5 Sieves

1.5.1 One piece sieve

The SELFRAG One piece sieves are durable and hard wearing. Life expectancy should be on the scale of years with sporadic use, they will become deformed with heavy use, and need replacing when they no longer form a sample tight connection with the opening of the process vessel shell. Frequent working with low gap and high voltage has been found to speed up warping of the sieves, decreasing life expectancy.

1.5.2 Compound Sieve

These are the combined wire mesh and metals plate sieves. We have had reports of the welding begin to break and the mesh begin to detach from the frame. Please bear in mind *that the SELFRAG Lab is a machine designed to break things*, including compound/welded metals. Damage appears to be focussed where the CE contacts the sieve mesh on the weld. Large amounts of energy cause impacts on the CE which are then transferred to the vessel via the sieve. Loading of stress will cause breakage (eventually) along this join. Sieve life can be enhanced by processing at lower voltages. Fine sieves (<1 mm) are more fragile and need more care as they can block when large amounts of material are processed at once (1 – 1.5 kg gravel, for example). The blocked sieve will receive the impact of the shockwave, enhancing damage. As such, use a larger gap 30 – 40 mm, lower voltages 120 – 150 kV, and monitor the fragmentation of the sample by processing in a series of pulses, as opposed to entering a value and leaving the machine. This will help avoid over processing and extend mesh life. Sharp or metallic components will increase mesh wear. In short, 1000 pulses at 200kV will probably destroy the compound sieve, and this is massively over-processing. I have found that around 80 – 90 % of a 250 g fine grained rock sample will have passed through a 0.320 mm sieve after 150 – 225 pulses.

1.5.3 Sandwich Sieve System

The plastic or metal mesh on the sandwich sieves are designed to be one use only for high purity/low contamination work using a screen. As they are thrown away after processing, there is no chance of material from a previous sample being trapped within the openings and contaminating the next sample. These sieves are of a low durability and high equipment settings could potentially cause puncturing of the mesh. As with the compound sieve in section 1.5.2, use a larger gap 30 – 40 mm, lower voltages 120 – 150 kV, and monitor the fragmentation of the sample by processing in a series of pulses, as opposed to entering a value and leaving the machine. This will help avoid over processing and extend mesh life. Sharp or metallic components will increase mesh wear.

1.5.4 Stage crushing

Reducing a material in size directly from bulky hand sample to sizes below 1 mm can require a lot of energy, causing sieve wear, and potential damage due to blockage. To work around this, material can be crushed in stages, meaning a finer material is processed to the final size. When breaking rocks down, one can use a coarser sieve, first e.g. 2 mm, reduce all material to below this size, dismount the process vessel, sieve treated product at the required size, then process the oversize using the final sieve required. This has the advantage of both pre-crushing/pre weakening the material, and also reducing feed volume. More time intensive (+ 6 – 8 mins per sample?) but your sieves will thank you.

The USP of SELFRAG is that we can liberate effectively at a coarser size than would normally be used, for example 0.25 mm sized zircon liberation might be sufficient when all material has passed through a 1 mm sieve, however this is anecdotal, lacking a thorough investigation.

2 General Safety

2.1 Production of waste gases during fragmentation

2.1.1 Sulphur rich material

The process vessel is essentially a chemical reaction chamber, with temperatures exceeding 5,000°K for fractions of a second (<500ns). While this generally causes no damage to materials, S rich material can undergo partial oxidation in water to create H_2S, identified by a rotten egg smell when opening the process chamber after treatment has finished. Please see the relevant H_2S/ material handling data sheet[1] for more information on the possible symptoms of H_2S exposure.

2.1.2 (Hydro) Carbon rich material

The process vessel is essentially a chemical reaction chamber, with temperatures exceeding 5,000°K for fractions of a second (<500ns). While this generally causes no damage to materials, C rich material, for example those listed in sections 4 and 5, can undergo partial oxidation to create CO and CO_2. . Please see the relevant CO/ material handling data sheet[2] for more information on the possible symptoms of CO exposure

2.1.3 Waste gas control measures

Appropriate measures should be taken when processing large amounts of C rich material, including:

- Processing in a well ventilated area – either open windows or a fan.
- Open process chamber doors after processing and leave vessel to stand for a moment to let any concentrations of gas dissipate
- Purchase/use of the **S**ELFRAG **WA**ste **G**as **E**xt**r**action **S**ystem (SWAGERS) Please contact SELFRAG for a fact sheet or quote.

[1] https://www.osha.gov/OshDoc/data_Hurricane_Facts/hydrogen_sulfide_fact.pdf
[2] https://www.osha.gov/OshDoc/data_General_Facts/carbonmonoxide-factsheet.pdf

3 Geological Materials

3.1 Metal Ores

3.1.1 Sulphide bearing ores

This category include rocks/ores containing S species, both sulphides and sulphates. These include porphyry deposit style ore, pyrite in shale, etc. S bearing minerals have the capacity to produce H_2S when processed. In this case, please exercise caution as described in section 2.1.1

3.1.2 Massive Sulphides

S bearing minerals have the capacity to produce H_2S when processed. In this case, please exercise caution as described in section 2.1.1. Massive sulphide materials can have a high capacity to conduct away the discharge, so process efficiency may be lowered.

3.1.3 Iron Ores

Massive Iron ore (BIF, IOCG etc.) have very high metal contents and as such are capable of conducting away the energy from the discharge. Internal tests showed that it can requires more energy to break certain massive Fe ore types, as the energy is used less efficiently. Increased process energy means greater wear. Hard to break down ores may be blasted into the vessel liner by the process shockwave, causing scratches.

3.2 Clays

3.2.1 Processing issues

When fragmentation occurs, clay material within the sample will go into suspension, clouding the water. This will have 2 effects:

1) Floating particles between the WE and sample will attract the discharge, decreasing breakage efficiency

2) Proportion of successful discharges will decrease due to difficulties discharging into cloudy water.

3) When water becomes opaque, the optical sensors will be triggered and the system will believe no water is present and will not process (error: Water level too low).

To solve these issues, pour away the cloudy water and replace with fresh DI water. Alternatively, SELFRAG has under development a vessel which allows the continuous flushing of fresh water. This should be available from 2017.

3.2.2 Retaining the clay fraction

If the clay fraction is of interest, the process water can be poured directly into a filter press for dewatering and collection of suspended clay phases, allowing 100 % recovery of the sample.

4 High Tech materials

4.1 Carbon Fibre

Not only are carbon fibres C rich (please see notes in section 2.1.2), the fibres are an irritant. Moving water during the emptying of the process vessel has the potential to splash into eyes, causing irritation. The SWAGERS SYSTEM (section 2.1.3) is recommended if extensive processing of C fibres is to take place. Additionally, hand, eye and respiratory protection are to be used when processing or handling these materials or their SELFRAG treated products.

4.2 Electronic Waste

4.2.1 Hard-drives

Desktop hard drives are often encased in a piece of solid metal, which means that they behave as a solid metal (see Section 6). It will require large amounts of energy to break open the metal casing of the hard drive. Once open, the discharges will begin to separate the internal components from the metal case. It is recommended that the metal case be cracked/cut before processing in the Lab. Large metal casings will often contact the PV liner, meaning discharges will be conducted from the metal casing into the liner, causing damage to the liner, deceasing life expectancy of the PV liner.

4.2.2 Motors

Motors are often encased in a piece of solid metal, which means that they behave as a solid metal (see Section 6). It will require large amounts of energy to break open the metal casing. Motors will break, however the large amount of metal can cause damage to or accelerate wear of the PV liner.

5 Construction and Demolition Waste

5.1 Road waste including Tarmac/Asphalt

Processing ‘sticky’ or greasy material such as tar, oil, asphalt, etc. will coat both the PV and contaminate the machine. While not physically damaging the PV liner will be stained black from the liberated material. This can also cause discolouration of the field concentrator on the electrode. If this material is to be processed regularly, we suggest having a dedicated PV liner for this purpose.

6 Processing Solid Metals

6.1 Don’t.

High Voltage pulses cannot treat/process pure metals as they conduct the discharge away, likely causing damage to the PV liner. If you regularly attempt to process pure/solid metals, you will cause rapid deterioration of the vessel liner.

7 Equipment care

7.1 Working Electrode Attachment Bolt

Important: The electrode tip should be tightened to a minimum 50Nm torque, and up to 65. With heavy/extensive processing (e.g., 1000 pulse cycles), the electrode tip will gradually loosen, and be able to move slightly with every shockwave when discharging. This has been found to strip the thread on the bolt holding it in place, which can then fall out. Checking WE torque should be part of the daily equipment checking, as part of the calibration process. This equipment will be checked as part of the standard lab service.

7.2 Contamination

The Lab system is generally self-contained, and causes virtually no contamination, however if several users operate the system for different purposes, improper cleaning can cause cross contamination of samples.

7.3 Cleaning of the Lab System

The Lab electrode area can be cleaned by filling the PV with clean water and discharging 100 times with a 10 mm electrode gap. Pure SiO_2 can also be used as a blank/abrasive to provide additional cleaning, much in the same way as a traditional mill. A cleaning routine could go:

Process sample > disassemble and clean process vessel > 100 discharges into 50g SiO_2 blank > disassemble and clean process vessel > 100 discharges into clean water > disassemble and clean process vessel > Process next sample.

7.4 The Micro Process Vessel (MPV)

To ensure contaminant free processing of small volumes of material, the MPV provides an enclosed process zone, which allows material neither in nor out.

8 Glossary of Terms

CE – Counter Electrode
MPV – Micro Process Vessel
PV – Process Vessel
SWaGERS – Selfrag Waste Gas Extraction/Removal System
WE – Working Electrode