Current status of the NA power converters
Summary of start up after LS2

Yves Gaillard / Xavier Genillon

SY/EPC

Photo © CERN Oct. 1980
OUTLINE

1. **Current status of NA power converters**
   1.1 Standard power converters (Nb > 300)
     • Generalities
     • Location
     • Types
     • Characteristics
     • What it looks like
     • Main concerns
   1.2 Spectrometer power converters (Nb: 15)
   1.3 Operation / Maintenance
   1.4 Consolidation plan

2. **LS2**
   2.1 Modifications during LS2
     • VME crate replacement
     • New interlock: CV Pump
     • P0 Survey improvements
   2.2 Summary of startup after LS2

3. **Conclusion**
1.1 Current status of standard NA Power converters

- **Generalities:**

  ✓ Transfer-lines magnets (from target to North area experiments) are supplied by standard thyristor power converters.

  ✓ 330 power converters (25kW → 3.6MW)
    50 spare PCs

  ✓ In operation since 1976 and never consolidated

  ✓ Responsibility: SY/EPC

  ✓ Power converter specialists:
    Yves GAILLARD
    Xavier GENILLON

  ✓ Operation 24/7: FSU TE11 (First line piquet)
1.1 Current status of standard Power converters

- Location:
1.1 Current status of standard Power converters

- Power converter types

  - 8 power converter types:
    - C11: 250A / 100V
    - R11: 500A / 150V
    - R12: 500A / 300V
    - R13: 500A / 225V
    - R21: 1000A / 300V
    - R22: 1500A / 250V
    - R31: 2500A / 255V

  - 2 voltage booster types:
    - D21: 1500A / 200V
    - D31: 2500A / 285V

  - Association (series or //) of power converters possible:
1.1 Current status of standard Power converters

- **Power converter characteristics**
  - Thyristor power converters (6P or 12P)
  - No output filters
  - Cooling: Air pulsed
    Water (EHN1 & SM2 Spectrometer)
  - Performances:
    - Current ripple: $10^{-3}$ to $10^{-4}$ of $I_{\text{max}}$
    - Low current operation:
      only C11 (Trim) + 9 R22 modified
  - Regulation:
    - Analog regulation (Voltage and current)
  - Control:
    - One VME crate per building
    - Remote control by CESAR
  - Magnet interlocks managed by PC, no WIC
1.1 Current status of standard Power converters

- What it looks like

Converter crate room

Original analog & digital electronics

Power part

Wire wrap technology
1.1 Current status of standard Power converters

- Main concerns

Main circuit breaker
Spare parts dwindling

Wire wrap
Obsolete components

Cabling ageing
Split insulation

Association of power converters: very difficult to troubleshoot
1.2 Current status of spectrometer Power converters

**SM2**

- 5000A/600V / Water cooling / RegFGC3
- Designed & built @ CERN in 2017
- Commissioned in 2015

**COMPASS Dipole & Solenoid**

- RPADC.EHN2.RDIP.COMPASS
- RPADC.EHN2.RSOL.COMPASS
- 700A/14V
- Designed & built @ CERN in 2013
- Commissioned in 2015

No Main concerns
1.2 Current status of spectrometer Power converters

M1 Superconducting magnet (H2)

Converter type: RPHG
4000A/8V
Power converter used in LHC
Control: FGC2/ Worldfip

No Main concerns
1.2 Current status of spectrometer Power converters

Vertex 1 & 2(H2) / ATLAS Morpugo (H8)

Superconducting magnets:

Renovated in 1995.
Will be replaced during YETS 2021/2022

Converter type: NS21
Thyristors Gradator
7000A/9V

Main concerns:
No spare power converter (only pieces)
LEP electronics obsolete
No remote control from CCC
1.2 Current status of spectrometer Power converters

- Association of standard power converters

GOLIATH 5000A/355V (NR31-01 //NR31-05)
DAVID 2500A/355V (NR31-06)
SM1 2500A/640V (NR31-03 + ND31-04)
MNP33_1 2600A/640V (NR31-07 + ND31-01)
MNP33_2 1500A/700V (NR22-56 + NR22-57 + ND21-60)
MNP22 1500A/250V (NR22-70)

- Same concerns as standard North area power converters
1.3 Operation / Maintenance

• Operation

• The MTBF of the power converter is very low: \( \sim 7000 \text{H} \)

• First line operation performed by FSU TE11 (24/7)

• Average intervention time: 1H

• Between 150 to 200 interventions during the run (\( \sim 1 \) intervention a day)

• Maintenance

• Special campaign:
  • Polarity switches cleaning and greasing 2017
  • Obsolete IC of the electronic cards change 2008 and 2013
  • Connectors of the electronics cards cleaning 2000
  • Fan bearings change (500 fans) 2001 and 2017
  • Tightening bus-bar and cable connections 2013
  • ...
1.4 Consolidation plan for NA Power converters

**YETS 2021/2022**

**VERTEX 1 & 2**

**ATLAS MORPUGO**

**LS3**
- 117 Converters

**LS4**
- 174 converters + GOLIATH DAVID MNP22
- 26 converters + MNP33-1 MNP33-2 SM1
2 LS2

2.1 Modifications during LS2

- Hardware of the control system:
  - Due to the obsolescence of the VME crate (WES), the 3 crates have been replaced by new ones (ULMA) in May 2021.
  - The 3 CPU cards have been replaced by MEN A25 type.
  - The power converters commissioning was done with these new crates without issue.

- Diagram:

```plaintext
22.06.2021
```

- Code:

```markdown
cfv-889-v2nb80
cfv-889-v2nb81
cfv-889-v2nb82
```
2 LS2

2.1 Modifications during LS2

- New global interlock: CV Pump OFF

✓ Since 2015, due to the sensors ageing the water pressure and the water temperature magnet interlocks were shunted by TE/MSC.

✓ The magnet protection is still assured by the Coil Temperature and TOS (Terminal Overload switch) interlocks.

✓ To avoid sending current into uncooled magnets, a new interlock has been implemented during LS2 via a cable connection between the EN/CV PLC and the VME crate of the power converters.

✓ Action: when the cooling of the building is OFF the power converters switch to standby mode (0A) and the fault Pump CV appears in CESAR.

✓ Modification validated in BA81 an BA82.
✓ Wiring modification to be done by EN / CV in BA80

ECR: SPS-NAFESA3-EC-0001
2 LS2

2.1 Modifications during LS2

• P0 Survey system reaction time improvements

The P0 magnet survey is a software, running in the POWJC front-end that compares actual currents to reference values of the power converters within a programmable tolerance. In case of deviations outside the tolerance, TAX-7 of the P42 beam is closed.

System response time = converter reaction time + TAX closing time (0.58mm/s)

We noticed that the reaction time of the converters was a little bit long and related to the number of converters installed of the building.

Converter reaction time after software modification

<table>
<thead>
<tr>
<th>Converter</th>
<th>Nb PC</th>
<th>Before LS2 (s)</th>
<th>After LS2 (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA80</td>
<td>117</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>BA81</td>
<td>177</td>
<td>50</td>
<td>11</td>
</tr>
<tr>
<td>BA82</td>
<td>30</td>
<td>10</td>
<td>4</td>
</tr>
</tbody>
</table>
2 LS2

2.2 Summary of startup NA power converters after LS2

- Special attention during the start-up period:
  - 330 power converters tested individually according to a rigorous procedure

- Start-up period:
  - 15/02 to 18/06/2021 (16 weeks)

- Sometimes difficult to perform the tests when the works in the tunnel are not completed. Fortunately, good collaboration between coordination team, EN/CV, TE/MSC and SY/EPC.

- To do before the end of this week: Thermal camera inspection on going
2 LS2

2.2 Summary of startup NA power converters after LS2

- Technical problems encountered during startup:
  
  ✓ Many auxiliary circuit breakers, hall probes, relays, electronic crates,…have been replaced.
  
  ✓ 130 electronic modules changed
    (that we need to troubleshoot, we have enough spare module)
  
  ✓ 27 Main circuit breakers replaced


Study and test in progress to replace it by a new type NSX630H already used on SIRIUS converters in other machine.

Please, use STANDBY mode to stop a converter
3. CONCLUSION

• Excepted few converters for spectrometer magnets, the North power converters are 45 years old.

• The MTBF of the power converter is very low: ~32H

• We need a lot of time for the commissioning after a LS (16weeks)

• Electronic reliability and end of life of MCBs are the main concerns

• Improvements can only come with a global consolidation program, foreseen in LS3 for BA80 and LS4 for BA81 and BA82

• Minor modification on power converters during LS2

• We have completed the converter tests respecting the schedule allocated by the coordination team.

• We would prefer that all works be completed in the tunnels before starting the converter tests.
Questions