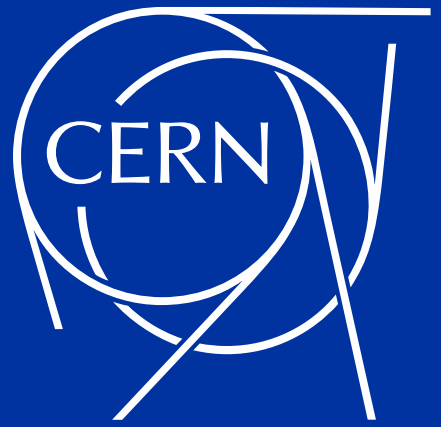



# PM- Rad Hard Cables Needs

David Belohrad, Stephane Burger, Michel Duraffourg, Aurelie Goldblatt, Stefano Mazzoni

BI/TB, physics: hard radiation cables 20.06.2024

# Detectors

- SEM
- BTV
- BRAN
- BWS

# SEM detectors in SPS

**More than 120 SEM detectors installed in the SPS injection line TT10 (BA1), TT20 (BA2), and North Area (BA80, BA81) (BSP, BSI, BSG, BSM, BBS, TBIU/D)**

**Cables connected from surface to detectors through intermediate racks in the tunnel**

- **Signal cables:**
  - Surface to intermediate racks: SBC36, connectors Burndy 50 rect
  - Intermediate racks to detectors: NE18, NE48, connectors Burndy (rect 50, round 4, 19, 48)
- **High Voltage cables:**
  - Before consolidation:
    - surface to intermediate racks: SBC36
    - Intermediate racks to detectors: rad hard SVHR2 (old version) or SVAR3, connector Burndy 4
  - After consolidation: general purpose CBH50, connector: 1HVPF

# Radiation Environment

**Discussion ticket RQF2484088 and Radiation survey (2018)**

**Target area (the most radioactive)**

- T2: 20 kGy/year , T4: 60 kGy/year, T6: 500 kGy/year
- Dose at wall level is divided by 10 → max 50kGy/year

- **NE “general purpose cables” : 100kGy max (see also cds 1248718)**
- **CBH50 : 560 kGy max (ref cds 1248718)**

# Signal Cables

**Surface to intermediate racks:**

- SBC36 cables from surface to intermediate racks installed in 1976.
- They are not maintained anymore by EN-EL cause missing tool.
- Consolidation was considered in 2022 but abandoned due to overall cost
- We never faced any issue with these cables

# Signal Cables

**Intermediate racks to detectors:**

- Some damaged cables were replaced (2009, 2014, 2018)
- Rad hard NER used only inside TBIU/D (cables that goes from target bottom shielding to the detector

**T6 SEM cabling situation (area with max dose) :**

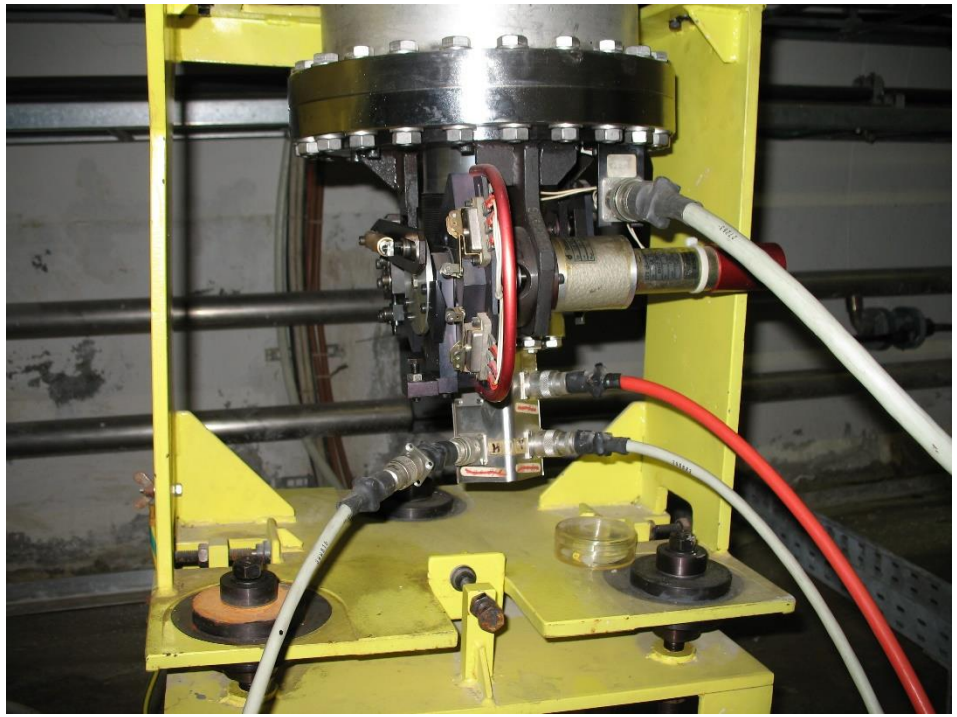
- NE48 cable from RA2509=TDC2 to RXBH251247=TCC2 (target bottom) installed in 2006
- No issue up to now

**Conclusion: We do not see any advantage in installing rad hard cables.**

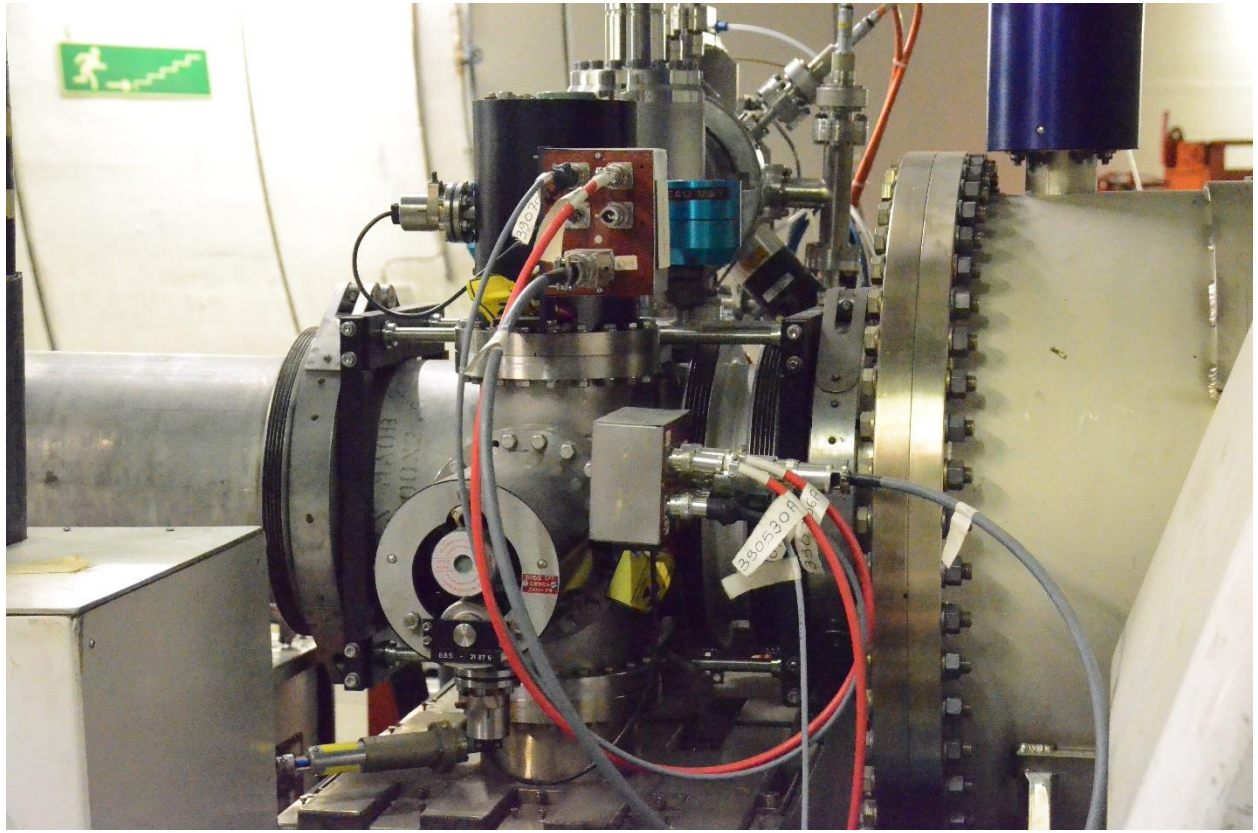
- Conservative option: move standard cables away from the beam line to the wall and connect rad hard short cables (4m) to the detectors

# High voltage cables: situation

SEM IN/OUT

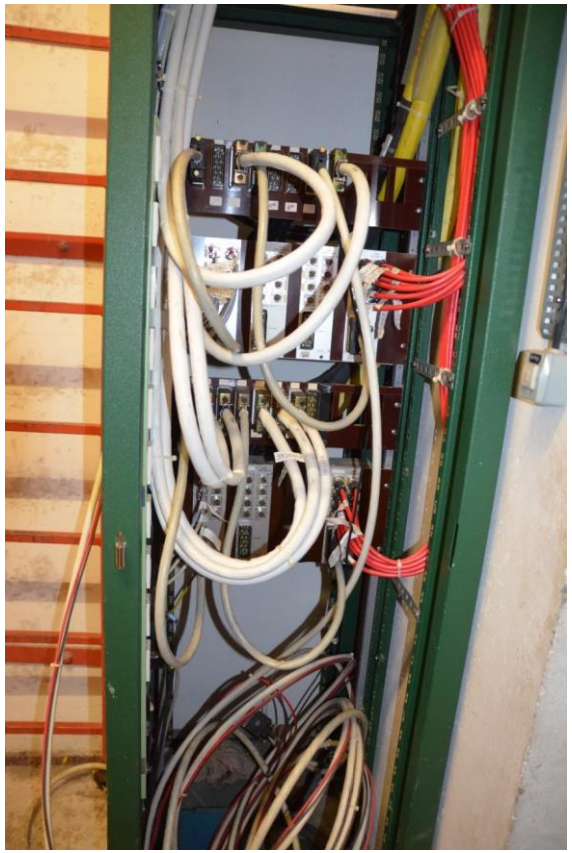


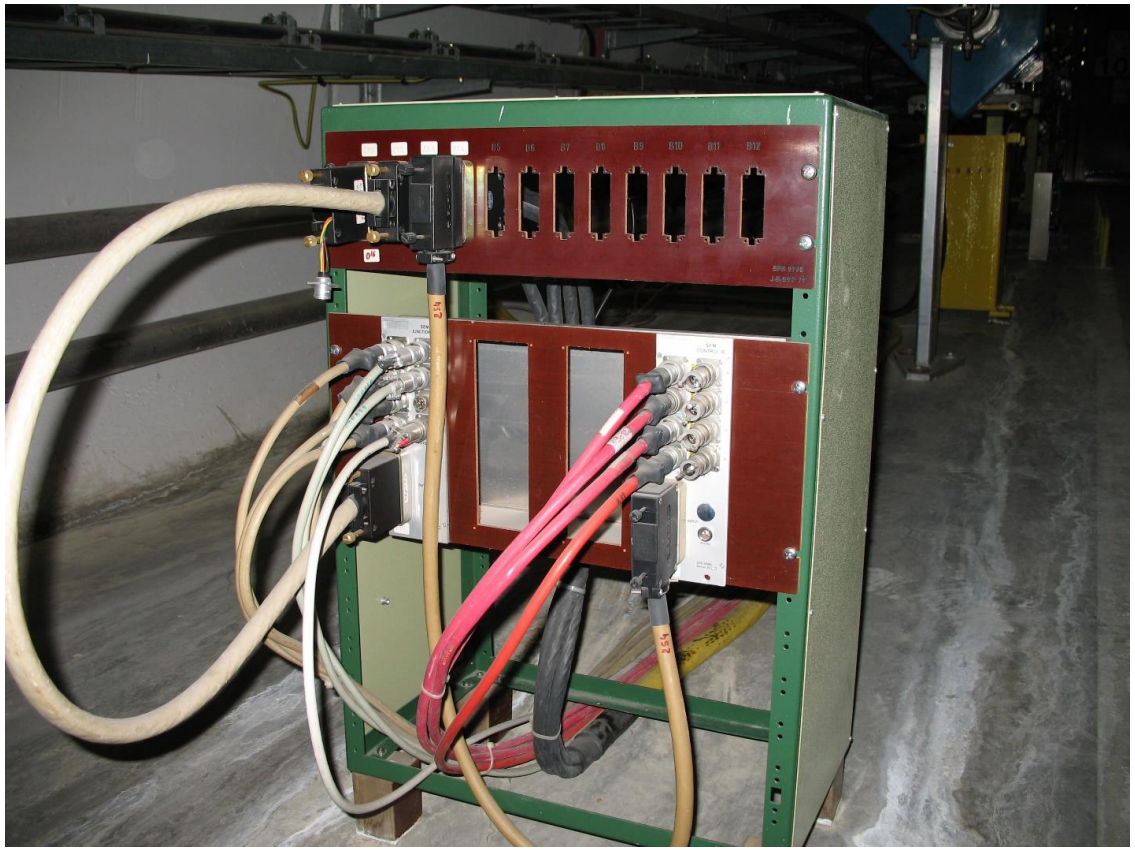
SEM with stepping motors



# High voltage cables: situation

Intermediate racks





# High voltage cables: situation

**Cables consolidation to comply with electrical safety (ref EDMS 1550773)**

**Cables replaced by CBH50 + 1HVPF + HVPF-to-Burndy adapter**

- BA1, BA2, BA81: cables replaced
- BA80 cables will be replaced during LS3
- Quote from Novacavi for rad hard cables (1HRS338):
  - 1.000,0 M 22,250 EUR/M
  - 2.000,0 M 16,850 EUR/M
  - 3.000,0 M 15,750 EUR/M
  - connector not provided, dose level tolerance not given

# High voltage cables: more infos

**Discussion with Simon Guerri (procurement)**

- **Novacavi doesn’t fulfill anymore CERN procurement requirements**
- **Jose Gascon (HSE-OHS-IB): infos about level of dose by location / rad hard cables needs**
- **Gianluca Canale (BE-EA-EC) advices about connectors**
- **List of companies for rad hard cables:**
  - Glenair UK: the only one that provides connectors but busy with war industry, big delivery delays
  - Axon
  - Allectra
  - Heatsense

# High voltage cables: Preferred option

- **Define areas where radiation level is critical :**
  **TDC2, TCC2, LSS2 :MST, MSE, ZS magnets area)**
  **→ 50 detectors**
- **Move long cables away from the beam lines to the wall**
- **Connect short cables (4m) to the detectors , to be replaced when damaged**
- **Cost per short cable (only material):**
  - Rad hard cable + Peek connectors = 230 CHF → overall cost = 11,5 kCHF
  - Standard cable + PE connectors = 100 CHF → overall cost = 5 kCHF
- **Conclusion : use rad hard short cables**
  - Less work, less contamination

# BTV

- **Few BTV are equipped with rad hard cables**
- **For new projects (or cables consolidation) in critical areas: preferred option same as SEM (ie short cables connected to the detector)**
- **Question from SB:**

  There will be the TCC2/TDC2 (BA80 basically) cabling renovation during LS3. Does EN-EL take care/advise on which cables should be rad hard (by location for example) ?

# BRAN (LHC – HL-LHC)

- **Critical areas: Pt1 and Pt5**
- **Cables concerned:**
  - High voltage, Coax and NE cables
  - from patch box to detector : ~5m
  - In operation since run3 (3 years), no issue
- **Preferred option:**
- Keep standard cables and replace when needed
- Use of signal cables type flexwells 7/8” (pre-DIC done).
  Rad tolerance unknown. Maybe not easy to have a rad hard version cause low-loss + high bandwidth

# BWS

- **PSB: short NER (rad hard) cables connected to the detectors**
- **SPS: standard cables, no issue**

# CARE (Cable Aging Research) working group

Re: North Area consolidation - radiation hard cables

FB

Federica Bortoletto
To Aurelie Noelle Goldblatt
Cc Jose Gascon; Marco Andreini

Reply | Reply All | Forward | ...

jeu. 20.06.2024 08:25

Dear Aurelie,
I answer to you on behalf of the CARE (Cable Ageing REsearch) working group supervised by Jose.

At CERN we identify three different categories of cables concerning radiation resistance, depending on the dose that the cable is foreseen to receive in service:

| Category | Dose in service | Dose for qualification in gamma |
|---|---|---|
| 1 | 100 Gy < x < 100 kGy | 500 kGy |
| 2 | 100 kGy < x < 700 kGy | 3.5 MGy |
| 3 | 700 kGy < x < 2 MGy | 10 MGy |

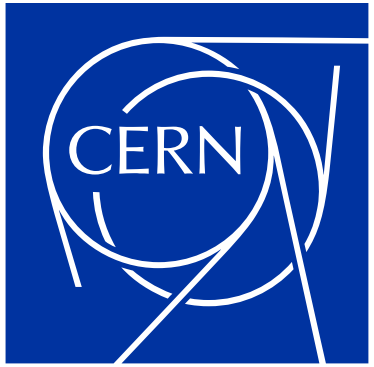
An estimation of the foreseen dose could be possibly provided by Monitoring and Calculation Working Group (MCWG). I do not know if you did already, but it could be useful to open a ticket to recover this information.
Once the cable Category has been identified, CARE can take care of the qualification of the cables that are going to be installed. Radiation resistance qualification is performed in 60Co gamma radiation, generally using a dose rate of 3.5-5 kGy/h. The dose at which the cable compliance is checked is 5 times (safety factor) the max dose that the cable is expected to receive in service condition (see last column of the table). After irradiation, the radiation resistance is generally evaluated by performing tensile tests on the cable polymeric components.

I rest available for further questions or clarifications,
Best regards,
Federica Bortoletto

# Documentation

**Radiation survey (2018)**
https://edms.cern.ch/ui/#!master/navigator/document?D:100769239:100769239:subDocs

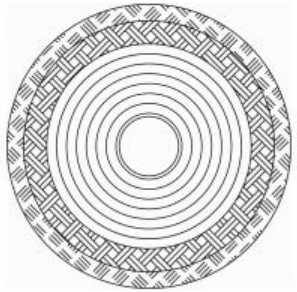
**Radiation Induced Aging Effects in Polymeric Cable Insulators at CERN**
https://cds.cern.ch/record/1248718/files/COMPILATION_DSC_FTIR_CERN_IRR_CABLES_SI.pdf




home.cern

# Spare slide: Novacavi cable specs

| 1x0,63 PI/TCBS/FGB 200°C | Specification 1HRS338 | |
|---|---|---|
| | Rev. 0 | Page 1/1 |



**CONSTRUCTION DETAILS**

Bare copper conductor 0,900 mm (1X0,63 mm2)
Dielectric with several polyimide tapes bonded together with thermosetting resin to the diameter of 3,15+/-0,15 mm
Bare copper braid shield, wire diameter 0,16 mm, coverage > 90%
Glass fiber impregnated braid, color red

Overall diameter 4,50+/-0,20 mm

**ELECTRICAL AND PHYSICAL CHARACTERISTICS**

| | |
|---|---|
| Electrical resistance conductors 0,63 mm2 | < 29,87 ohm/km @ 20°C |
| Screen electrical resistance | < 10,62 ohm/km @ 20°C |
| Insulation resistance | > 10 Mohm*km |
| Nominal capacitance | : 160 pF/m |
| Characteristic impedance @ 1 MHz | : 50+/-10 ohm |
| Weight | : 38 kg/km |
| Recommended static bending radius min. | : 45 mm |
| Working temperature | : -60/+200°C |

**REFERENCE STANDARDS**

CEI, IEC

# Max dose CBH50 vs SVAR-3

**2.1 Compilation of the DSC life-time evaluation data**

| Cable data | | | Irradiation conditions | | | Laboratory measurements and results | | | | | DSC parameters/ remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type/ Lab. code/ Function | Supplier/ production date | Material | Radiation / Sample form | Dose rate kGy/h | Dose (kGy) | OIT (min.) | k' ($kGy^{-1}$) | Maximum supportable dose, $D_x$ (kGy) | Life-time (rounded) | RI | |
| **Silec/ 1/ jacket** | Silec Cable, FR/ ~1995 | **EVA type I (black)** | $\gamma^{137}$Cs/ **strap** | - | 0 | 460 | $1.16 \cdot 10^{-3}$ | **683** | **1700 h** | **5.8** | isothermal, 190 °C, air |
| | | | | 0.4 | 9.6 | 490 | | | | | |
| | | | | 0.4 | 28.8 | 391 | | | | | |
| | | | | 0.4 | 96 | 164 | | | | | |
| | | | $\gamma^{60}$Co/ **bulk-air** | - | 0 | 460 | $5.47 \cdot 10^{-3}$ | **1448** | **950 h** | **6.2** | isothermal, 190 °C, air |
| | | | | 1.5 | 310 | 82 | | | | | |
| | | | | 1.5 | 630 | 18 | | | | | |
| **NG-18/ 9/ jacket** | Draka Comteq, DE/ 2006w19 | **EVA type I (white)** | $\gamma^{137}$Cs/ **bulk-air** | - | 0 | 343 | $1.06 \cdot 10^{-2}$ | **720** | **1800 h** | **5.9** | isothermal, 210 °C, air |
| | | | | 0.4 | 9.6 | 240 | | | | | |
| | | | | 0.4 | 28.8 | 266 | | | | | |
| | | | | 0.4 | 96 | 201 | | | | | |
| | | | $\gamma^{60}$Co/ **bulk-air** | - | 0 | 343 | $9.42 \cdot 10^{-3}$ | **810** | **2000 h** | **5.9** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 8 | | | | | |
| | | | | 1.5 | 630 | 1.9 | | | | | |
| | | | $\gamma^{60}$Co/ **bulk-enc.** | - | 0 | 343 | $8.27 \cdot 10^{-3}$ | **922** | **2300 h** | **6.0** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 21 | | | | | |
| | | | | 1.5 | 630 | 2.8 | | | | | |
| **CC-50/ 22/ jacket** | Draka Comteq, DE/ 2002 | **EVA type I (brown)** | $\gamma^{60}$Co/ **bulk-enc.** | - | 0 | 369 | $9.28 \cdot 10^{-3}$ | **830** | **550 h** | **5.9** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 12 | | | | | |
| | | | | 1.5 | 630 | 1.3 | | | | | |
| | | | $\gamma^{60}$Co/ **bulk-enc.** | - | 0 | 152 | $8.96 \cdot 10^{-3}$ | **760** | **500 h** | **5.9** | OIT at 210 °C as calculated from non-isothermal measurements |
| | | | | 1.5 | 310 | 5.5 | | | | | |
| | | | | 1.5 | 630 | 0.7 | | | | | |
| **CBH-50/ 23/ jacket** | Draka Comteq, DE/ 2006 | **EVA type I (red)** | $\gamma^{60}$Co/ **bulk-enc.** | - | 0 | 706 | $2.949 \cdot 10^{-3}$ | **2831** | **1900 h** | **6.5** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 101 | | | | | |
| | | | | 1.5 | 630 | 161 | | | | | |

| Cable data | | | Irradiation conditions | | | Laboratory measurements and results | | | | | DSC parameters/ remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type/ Lab. code/ Function | Supplier/ production date | Material | Radiation / Sample form | Dose rate kGy/h | Dose (kGy) | OIT (min.) | k' ($kGy^{-1}$) | Maximum supportable dose, $D_x$ (kGy) | Life-time (rounded) | RI | |
| | w49 | | | | | | | | | | |
| **SVAR-3/ 38b/ jacket** | Raydex | **EVA type II (red)** | $\gamma^{60}$Co/ **bulk-air** | - | 0 | 5834 | $1.01 \cdot 10^{-3}$ | **10352** | **6900 h** | **7.0** | OIT at 210 °C as calculated from non-isothermal measurements |
| | | | | 1.5 | 3000 | 278 | | | | | |
| | | | $\gamma^{60}$Co/ **bulk-air** | - | 0 | 5834 | $1.43 \cdot 10^{-4}$ | **19919** | **950 h** | **7.3** | OIT at 210 °C as calculated from non-isothermal measurements |
| | | | | 21.1 | 10000 | 573 | | | | | |
| | | | | 21.1 | 20000 | 473 | | | | | |
| | | | $\gamma^{60}$Co/ **bulk-enc.** | - | 0 | 5834 | $1.55 \cdot 10^{-4}$ | **18377** | **850 h** | **7.3** | OIT at 210 °C as calculated from non-isothermal measurements |
| | | | | 21.1 | 10000 | 1213 | | | | | |
| **TFA-3/ 39/ jacket** | Draka Multimedia DE 1998 (J98-0535) | **EVA type II (orange)** | $\gamma^{60}$Co/ **bulk-air** | | 0 | 2475 | $2.995 \cdot 10^{-3}$ | **3212** | **2150 h** | **6.5** | OIT at 210 °C as calculated from non-isothermal measurements |
| | | | | 1.5 | 310 | 790 | | | | | |
| | | | | 1.5 | 630 | 398 | | | | | |

# Max dose NG-18 (jacket and insulation)

| Cable data | | | Irradiation conditions | | | Laboratory measurements and results | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type/ Lab. code/ Function | Supplier/ production date | Material | Radiation/ Sample form | Dose rate kGy/h | Dose (kGy) | OIT (min.) | k' ($kGy^{-1}$) | Maximum supportable dose, $D_x$(kGy) | Life-time (rounded) | RI | DSC parameters/ remarks |
| | | | | | | | | | | | *as it was communicated* |
| **PB-300/ 7/ insulation** | unknown/ stored in CERN ~ 30 years | **LDPE** | PS Septum SEH 31 R/ **bulk** | - | 0 | 104 | **$8.71 \cdot 10^{-2}$** | **74** | unknown irradiation time | **4.9** | isothermal, 190 °C, air/ *excessively small dose (!), as it was communicate* |
| | | | | n.a. | 0.800 | 97 | | | | | |
| **PB-300/ 8/ insulation** | unknown/ stored in CERN ~ 30 years | **LDPE** | PS Septum SEH 31T/ **bulk** | - | 0 | 104 | unknown dose and irradiation time | | | | isothermal, 190 °C, air |
| | | | | n.a. | n.a. | 93 | | | | | |
| **PB-300/ 4/ jacket** | unknown/ stored in CERN ~ 30 years | **LDPE** | $\gamma^{137}$ Cs/ **strap** | - | 0 | 229 | **$2.69 \cdot 10^{-2}$** | **269** | **670 h** | **5.4** | isothermal, 190 °C, air |
| | | | | 0.4 | 9.6 | 216 | | | | | |
| | | | | 0.4 | 28.8 | 105 | | | | | |
| | | | | 0.4 | 96 | 17 | | | | | |
| | | **LDPE** | $\gamma^{60}$ Co/ **bulk-air**, inner part | - | 0 | 229 | **$7.74 \cdot 10^{-2}$** | **933** | **620 h** | **6.0** | isothermal, 190 °C, air |
| | | | | 1.5 | 310 | 10 | | | | | |
| | | | | 1.5 | 630 | 3.3 | | | | | |
| **NG-18/ 9/ insulation (white)** | Draka Comteq DE/ 2006w19 | **LDPE** | $\gamma^{137}$ Cs/ **bulk-air** | - | 0 | 148 | **$1.27 \cdot 10^{-1}$** | **53** | **130 h** | **4.7** | isothermal, 190 °C, air |
| | | | | 0.4 | 9.6 | 40 | | | | | |
| | | | | 0.4 | 28.8 | 4 | | | | | |
| | | | | 0.4 | 96 | 0 | | | | | |
| | | | $\gamma^{137}$ Cs/ **bulk-enc.** | - | 0 | 148 | **$7.63 \cdot 10^{-2}$** | **89** | **220 h** | **4.9** | isothermal, 190 °C, air |
| | | | | 0.4 | 9.6 | 46 | | | | | |
| | | | | 0.4 | 28.8 | 19 | | | | | |
| | | | | 0.4 | 96 | 11 | | | | | |
| | | | $\gamma^{60}$ Co/ **bulk-air** | - | 0 | 148 | - | **<310** | **<200 h** | - | isothermal, 190 °C, air |
| | | | | 1.5 | 310 | 0 | | | | | |
| | | | | 1.5 | 630 | 0 | | | | | |
| | | | $\gamma^{60}$ Co/ **bulk-** | - | 0 | 148 | - | **<310** | **<200 h** | - | isothermal, 190 °C, air |
| | | | | 1.5 | 310 | 0 | | | | | |

22

| Cable data | | | Irradiation conditions | | | Laboratory measurements and results | | | | | DSC parameters/ remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type/ Lab. code/ Function | Supplier/ production date | Material | Radiation / Sample form | Dose rate kGy/h | Dose (kGy) | OIT (min.) | k' ($kGy^{-1}$) | Maximum supportable dose, $D_x$ (kGy) | Life-time (rounded) | RI | |
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| | | | | 0.4 | 9.6 | 490 | | | | | |
| | | | | 0.4 | 28.8 | 391 | | | | | |
| | | | | 0.4 | 96 | 164 | | | | | |
| | | | $\gamma^{60}$ Co/ **bulk-air** | - | 0 | 460 | **$5.47 \cdot 10^{-3}$** | **1448** | **950 h** | **6.2** | isothermal, 190 °C, air |
| | | | | 1.5 | 310 | 82 | | | | | |
| | | | | 1.5 | 630 | 18 | | | | | |
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| | | | | 0.4 | 9.6 | 240 | | | | | |
| | | | | 0.4 | 28.8 | 266 | | | | | |
| | | | | 0.4 | 96 | 201 | | | | | |
| | | | $\gamma^{60}$ Co/ **bulk-air** | - | 0 | 343 | **$9.42 \cdot 10^{-3}$** | **810** | **2000 h** | **5.9** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 8 | | | | | |
| | | | | 1.5 | 630 | 1.9 | | | | | |
| | | | $\gamma^{60}$ Co/ **bulk-enc.** | - | 0 | 343 | **$8.27 \cdot 10^{-3}$** | **922** | **2300 h** | **6.0** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 21 | | | | | |
| | | | | 1.5 | 630 | 2.8 | | | | | |
| **CC-50/ 22/ jacket** | Draka Comteq, DE/ 2002 | **EVA type I (brown)** | $\gamma^{60}$ Co/ **bulk-enc.** | - | 0 | 369 | **$9.28 \cdot 10^{-3}$** | **830** | **550 h** | **5.9** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 12 | | | | | |
| | | | | 1.5 | 630 | 1.3 | | | | | |
| | | | $\gamma^{60}$ Co/ **bulk-enc.** | - | 0 | 152 | **$8.96 \cdot 10^{-3}$** | **760** | **500 h** | **5.9** | OIT at 210 °C as calculated from non-isothermal measurements |
| | | | | 1.5 | 310 | 5.5 | | | | | |
| | | | | 1.5 | 630 | 0.7 | | | | | |
| **CBH-50/ 23/ jacket** | Draka Comteq, DE/ 2006 | **EVA type I (red)** | $\gamma^{60}$ Co/ **bulk-enc.** | - | 0 | 706 | **$2.949 \cdot 10^{-3}$** | **2831** | **1900 h** | **6.5** | isothermal, 210 °C, air |
| | | | | 1.5 | 310 | 101 | | | | | |
| | | | | 1.5 | 630 | 161 | | | | | |