Cooldown Numbers

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D-Zero Engineering Note 3740.000-EN-106

Report on cooldown refrigeration of D-Zero cryostats

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*****
*          Density of materials in cryostat          *
*                                                    *
*          Copper - 8.96 g/cc                        *
*          G-10 - 1.7 g/cc                          *
*          Uranium - 19.0 g/cc                      *
*          Stainless Steel (304) - 8.03 g/cc         *
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*****
*          Enthalpy change of materials (300K-90K)   *
*                                                    *
*          Copper - 73.75 J/g                        *
*          G-10 - 110 J/g                          *
*          Uranium - 22.15 J/g                      *
*          Stainless Steel (304) - 70 J/g           *
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*****
*          Weight of end cryostat (EC)               *
*                                                    *
*          Copper - 125.16 tons =  $1.14 \times 10^8$  g    *
*          G-10 - 2.65 tons =  $2.41 \times 10^6$  g      *
*          Uranium - 59.27 tons =  $5.39 \times 10^7$  g    *
*          304SS - 41.95 tons =  $3.81 \times 10^7$  g     *
*          LAr - 12.7 tons =  $1.15 \times 10^7$  g       *
*                                                    *
*          Total = 224.6 tons =  $2.04 \times 10^8$  g    *
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*****
*          Weight of center cryostat                 *
*                                                    *
*          Copper - 117.14 tons =  $1.06 \times 10^8$  g    *
*          G-10 - 5.07 tons =  $4.61 \times 10^6$  g      *
*          Uranium - 156.9 tons =  $1.43 \times 10^8$  g    *
*          304SS - 31.5 tons =  $2.86 \times 10^7$  g     *
*          LAr - 30.33 tons =  $2.76 \times 10^7$  g       *
*                                                    *
*          Total = 325.16 tons =  $2.96 \times 10^8$  g    *
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*****
*                               *
*      Cooldown loads of an end cryostat      *
*                               *
*      Copper -  $8.41 \times 10^9$  J      *
*      6-10 -  $2.65 \times 10^8$  J      *
*      Uranium -  $1.20 \times 10^9$  J      *
*      304SS -  $2.67 \times 10^9$  J      *
*                               *
*      Total =  $1.25 \times 10^{10}$  J      *
*****

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*****
*                               *
*      Cooldown loads of central cryostat      *
*                               *
*      Copper -  $7.82 \times 10^9$  J      *
*      6-10 -  $5.07 \times 10^8$  J      *
*      Uranium -  $3.17 \times 10^9$  J      *
*      304SS -  $2.00 \times 10^9$  J      *
*                               *
*      Total =  $1.35 \times 10^{10}$  J      *
*****

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*****
*                               *
*      Total load of an end cryostat      *
*                               *
*       $1.25 \times 10^{10}$  J + 5 Kw (est.)      *
*                               *
*      Max. refrigeration available: 45 Kw @ 88K      *
*                               *
*      Min. time to cooldown: 73.1 hours      *
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*****
*                               *
*      Total load on center cryostat      *
*                               *
*       $1.35 \times 10^{10}$  J + 5 Kw (est.)      *
*                               *
*      Max. refrigeration available: 45 Kw @ 88K      *
*                               *
*      Min. time to cooldown: 79.0 hours      *
*****

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