APPENDIX B
AMS-02 Thermal Control System (TCS)
Heater Properties

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
PDS (internal), Bus A	714 (@ 113V on ISS) 630 (@ 106.1V on PVGF)	106.1 (PVGF) 113 (ISS)	126.5	Open-On-Rise -30 / +3 (tbc) Open-On-Rise -45/-14(tbc) Close-On-Rise -48/-45(tbc) Open-On-Rise -30/-5 Close-On-Rise -30/-35(tbc)	dual heater elements	7	3 heater patches (270W) controlled by one OOR thermostat each; 2 heater patches (180W) controlled by one OOR thermostat in series to one COR thermostat each; 2 heater patches (180) controlled by one OOR thermostat in series to one COR thermostat each	No; Each patch is equipped by a safety thermostat	Glued to back side of radiator over heat pipes dedicated flanges	PDS is equipped by thermal interlock close on-rise thermostats (2+2 in parallel) that control the PDS switch-on. When PDS thermal interlock thermostats reach -18°C+/-1.7 , thermostats close and PDS circuits may start working. These thermostats remain always close nominally when PDS is on (if thermostat temperature remain above -23°C+/- 1.7 , the minimum operative temperature of the pds). PDS heaters are enabled when payload receives power from ISS (provided that thermostats are closed). When PDS reaches "switch-on" temperature, PDS heaters are NOT "istantly" disabled
PDS (internal), Bus B	As above	As above	As above	As above	As above	As above	As above	As above	As above	As above
Tracker Radiator (including condensers) – Ram – BUS A	155,9	113 @ ISS (we are not going to operate these heaters in hand-off)	126.5	-35°C / -25 (tbc by NLR)	Single element heater	55	3 thermostats in series+PDS Line A10	No	Glued to back side of radiator near heat pipes and on TTCS condensers	Needed to defreeze ammonia heat pipes and CO2 prior to Tracker operation. Will be disabled after start-up.

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
Tracker Radiator (including condensers) – Ram – BUS B	155,9	see above	126.5	-35°C / -25 (tbc by NLR)	Single element heater	55	2 thermostats in series+PDS Line B10	No	Glued to back side of radiator near heat pipes and on TTCS condensers	Needed to defreeze ammonia heat pipes and CO2 prior to Tracker operation. Will be disabled after start-up.
Tracker Radiator (including condensers) – Wake - BUS A	155,9	see above	126.5	-35°C / -25 (tbc by NLR)	Single element heater	55	2 thermostats in series+PDS Line A4	No	Glued to back side of radiator near heat pipes and on TTCS condensers	Needed to defreeze ammonia heat pipes and CO2 prior to Tracker operation. Will be disabled after start-up.
Tracker Radiator (including condensers) – Wake - BUS B	155,9	see above	126.5	-35°C / -25 (tbc by NLR)	Single element heater	55	2 thermostats in series+PDS Line B4	No	Glued to back side of radiator near heat pipes and on TTCS condensers	Needed to defreeze ammonia heat pipes and CO2 prior to Tracker operation. Will be disabled after start-up.
Main Radiator – Ram (set#1) – BUS A	430 @ 106.1V (at PVGF) 488 @ 113V (on ISS)	106.1 (PVGF) 113 (ISS)	126.5	-18C/-12C	Dual element heater	12	3 thermostats in series+PDS Line 2A	No (Each patch is equipped by a safety thermostat)	Double sided heaters glued to back side of radiator	Needed when electronics are off and to switch-on J group Will be disabled after start-up.
Main Radiator – Ram (set#1) – BUS B	see above	see above	126.5	-18C/-12C	Dual element heater	12	3 thermostats in series + PDS Line 2B	No (Each patch is equipped by a safety thermostat)	Double sided heaters glued to back side of radiator	Needed when electronics are off and to switch-on J group Will be disabled after start-up.
Main Radiator – Ram (set#2) – BUS A	350 @ 113V	113 ISS (we are not going to operate these heaters when we are on the SSRMS)	126.5	-18C/-12C	Dual element heater	9	3 thermostats in series + PDS Line 5A	No (Each patch is equipped by a safety thermostat)	Double sided heaters glued to back side of radiator	Needed for startup of the electronics but J group. Will be disabled after start-up.
Main Radiator – Ram (set#2) – BUS B	350 @ 113V	113 ISS (we are not going to operate	126.5	-18C/-12C	Dual element heater	9	3 thermostats in series + PDS Line 5B	No (Each patch is equipped by a safety	Double sided heaters glued to back side of radiator	Needed for startup of the electronics but J group. Will be disabled after start-up.

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
		these heaters when we are on the SSRMS)						thermostat)		
Main Radiator – Wake- BUS A	129 @ 113V on ISS	113 ISS (we are not going to operate these heaters when we are on the SSRMS)	126.5	-18C/-12C	Dual element heater	6	3 thermostats in series + PDS Line A8	No (Each patch is equipped by a safety thermostat)	Double sided heaters glued to back side of radiator	Needed for startup and when electronics are off. Will be disabled after start-up.
Main Radiator – Wake - - BUS B	129 @ 113V on ISS	113 ISS (we are not going to operate these heaters when we are on the SSRMS)	126.5	-18C/-12C	Dual element heater	6	3 thermostats in series + PDS Line B8	No (Each patch is equipped by a safety thermostat)	Double sided heaters glued to back side of radiator	Needed for startup and when electronics are off. Will be disabled after start-up.
Cryo-cooler I - Primary LHP - BUSA	34,25 @ 113V (on ISS)	113 ISS (we are not going to operate these heaters when we are on the SSRMS)	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A9	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler I - Primary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B9	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler I - Secondary LHP- BUSA	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A9	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
Cryo-cooler I - Secondary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B9	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler II - Primary LHP- BUSA	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A9	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler II - Primary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B9	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler II - Secondary LHP- BUSA	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A9	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler II - Secondary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B9	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler III - Primary LHP- BUSA	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A11	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler III - Primary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B11	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler III - Secondary LHP- BUSA	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A11	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler III - Secondary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B11	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler 0 - Primary LHP- BUSA	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A11	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler 0 - Primary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B11	No	Glued to Primary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler 0 - Secondary LHP- BUSA	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS A11	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)
Cryo-cooler 0- Secondary LHP- BUSB	34,25 @ 113V (on ISS)	as above	126.5	-8C/-3.5C (TBC)	Dual element heater	1	1 thermostat + PDS B11	No	Glued to Secondary LHP evaporator + bolt-on cover plate.	Needed to startup LHP and to maintain Cryocooler above -10C (TBC)

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
TRDGB C-box pump canister	11.4	113	126.5	+10C/+15C	Kapton foil	2	1 thermostat + PDS Line A3 (shared thermostat with valves)	No	Glued to surface of pump canister	Enabled during operation.
TRDGB C-box pump canister	11.4	113	126.5	+10C/+15C	Kapton foil	2	1 thermostat + PDS Line B3 (shared thermostat with valves)	No		Enabled during operation.
TRDGB C-box valves	3.6	113	126.5	+10C/+15C	resistor	4	1 thermostat + PDS Line A3 (shared thermostat with canister)	No		Enabled during operation.
TRDGB C-box valves	3.6	113	126.5	+10C/+15C	resistor	4	1 thermostat + PDS Line B3 (shared thermostat with canister)	No		Enabled during operation.
TRDGB Lower 2-valve block	6.2	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line A3	No		Enabled during operation.
TRDGB Lower 2-valve block	6.2	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line B3	No		Enabled during operation.
TRDGB Upper 2-valve block	4.5	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line A3	No		Enabled during operation.
TRDGB Upper 2-valve block	4.5	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line B3	No		Enabled during operation.
TRDGB Vent valve	3.2	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line A3	No		Enabled during operation.
TRDGB Vent valve	3.2	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line B3	No		Enabled during operation.
TRDGB 4-valve Block	8	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line A3	No		Enabled during operation.
TRDGB 4-valve Block	8	113	126.5	+10C/+15C	resistor	2	1 thermostat + PDS Line B3	No		Enabled during operation.

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
CAB BUS A	99,5	113 ISS (we are not going to operate these heaters when we are on the SSRMS)	126.5	-20C/-14C (TBC)	Kapton Foil	5	2 thermostats + PDS Line A8	No	Double sided heater glued to CAB housing	
CAB BUS B	99,5	113 ISS (we are not going to operate these heaters when we are on the SSRMS)	126.5	-20C/-14C (TBC)	Kapton Foil	5	2 thermostats + PDS Line B8	No	Double sided heater glued to CAB housing	
RICH, Ram (+Ram/Port) Bus A	15,4 @ 106.1V (at PVGF) 17,5 @ 113V (on ISS)	106.1 (at PVGF) 113 (on ISS)	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line A7	No	Double sided heater glued to octagonal structure	Enabled during operation.
RICH, Ram (+Ram/Port) Bus B	see above	see above	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line B7	No	Double sided heater glued to octagonal structure	Enabled during operation.
RICH, Port (+Port/Wake) Bus A	see above	see above	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line A7	No	Double sided heater glued to octagonal structure	Enabled during operation.
RICH, Port (+Port/Wake) Bus B	see above	see above	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line B7	No	Double sided heater glued to octagonal structure	Enabled during operation.
RICH, Wake (+Wake/Starboard) Bus A	see above	see above	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line A7	No	Double sided heater glued to octagonal structure	Enabled during operation.

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
RICH, Wake (+Wake/Starboard) Bus B	see above	see above	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line B7	No	Double sided heater glued to octagonal structure	Enabled during operation.
RICH, Starboard (+Starboard/Ram) Bus A	see above	see above	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line A7	No	Double sided heater glued to octagonal structure	Enabled during operation.
RICH, Starboard (+Starboard/Ram) Bus B	see above	see above	126.5	-27C/-21C	Kapton Foil	2	1 thermostat + PDS Line B7	No	Double sided heater glued to octagonal structure	Enabled during operation.
ECAL, Starboard Bus A	15,4 @ 106.1V at PVGF 17,5 @ 113V on ISS	106.1 (at PVGF) 113 (on ISS)	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line A1	No	Double sided heater glued to back of radiator structure	Enabled during operation.
ECAL, Starboard Bus B	see above	113	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line B1	No	Double sided heater glued to back of radiator structure	Enabled during operation.
ECAL, Wake Bus A	see above	113	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line A1	No	Double sided heater glued to back of radiator structure	Enabled during operation.
ECAL, Wake Bus B	see above	113	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line B1	No	Double sided heater glued to back of radiator structure	Enabled during operation.
ECAL, Port Bus A	see above	113	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line A1	No	Double sided heater glued to back of radiator structure	Enabled during operation.
ECAL, Port Bus B	see above	113	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line B1	No	Double sided heater glued to back of radiator structure	Enabled during operation.
ECAL, Ram Bus A	see above	113	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line A1	No	Double sided heater glued to back of radiator structure	Enabled during operation.

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
ECAL, Ram Bus B	see above	113	126.5	-18C/-12C	Kapton Foil	4	1 thermostat + PDS Line B1	No	1 Double sided heater glued to each of the two E-crates	Enabled during operation.
E-crate (E-0) Bus A	26,5 @ 106.1V at PVGF 30,0 @ 113V on ISS	106.1 (at PVGF) 113 (on ISS)	126.5	-18C/-12C	Kapton Foil	1	1 thermostat + PDS Line A6	No	1 Double sided heater glued to the bottom plate of the E-crate housing	
E-crate (E-0) Bus B	see above	see above	126.5	-18C/-12C	Kapton Foil	1	1 thermostat + PDS Line B6	No	1 Double sided heater glued to the bottom plate of the E	
E-crate (E-1) Bus A	see above	see above	126.5	-18C/-12C	Kapton Foil	1	1 thermostat + PDS Line A6	No	1 Double sided heater glued to the bottom plate of the E	
E-crate (E-1) Bus B	see above	see above	126.5	-18C/-12C	Kapton Foil	1	1 thermostat + PDS Line B6	No	1 Double sided heater glued to the bottom plate of the E	
Lower TOF, +X Bus A	6,6 @ 106.1 at PVGF 7,5 @ 113 on ISS	106.1 (at PVGF) 113 (on ISS)	126.5	-27C/-21C	Kapton Foil	1	1 thermostat + PDS Line A7	No	1 Double sided heater glued to TOF structure	Enabled during operation.
Lower TOF, +X Bus B	See above	see above	126.5	-27C/-21C	Kapton Foil	1	1 thermostat + PDS Line B7	No	1 Double sided heater glued to TOF structure	Enabled during operation.
Lower TOF, +Y Bus A	8,3 @ 106.1 at PVGF 9,4 @ 113 on ISS	106.1 (at PVGF) 113 (on ISS)	126.5	-27C/-21C	Kapton Foil	3	1 thermostat + PDS Line A7	No	1 Double sided heater glued to TOF structure	Enabled during operation.
Lower TOF, +Y Bus B	See above	see above	126.5	-27C/-21C	Kapton Foil	3	1 thermostat + PDS Line B7	No	1 Double sided heater glued to TOF structure	Enabled during operation.
Lower TOF, -X Bus A	6,6 @ 106.1 at PVGF 7,5 @	106.1 (at PVGF) 113 (on ISS)	126.5	-27C/-21C	Kapton Foil	1	1 thermostat + PDS Line A7	No	1 Double sided heater glued to TOF structure	Enabled during operation.

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
	113 on ISS									
Lower TOF, -X Bus B	see above	see above	126.5	-27C/-21C	Kapton Foil	1	1 thermostat + PDS Line B7	No	1 Double sided heater glued to TOF structure	Enabled during operation.
Lower TOF, -Y Bus A	8,3 @ 106.1 at PVGF 9,4 @ 113 on ISS	106.1 (at PVGF) 113 (on ISS)	126.5	-27C/-21C	Kapton Foil	3	1 thermostat + PDS Line A7	No	1 Double sided heater glued to TOF structure	Enabled during operation.
Lower TOF, -Y Bus B	See above	See above	126.5	-27C/-21C	Kapton Foil	3	1 thermostat + PDS Line B7	No	1 Double sided heater glued to TOF structure	Enabled during operation.
EHV & RHV Bricks (10 High Voltage Boxes total) Bus A	66 @ 106.1 at PVGF 75 @ 113 on ISS	106.1 (at PVGF) 113 (on ISS)	126.5	-18C/-12C	Kapton Foil	10	1 thermostat per brick + PDS Line A6	No	1 Double sided heater glued inside each brick box	
EHV & RHV Bricks (10 total) Bus B	see above	see above	126.5	-18C/-12C	Kapton Foil	10	1 thermostat per brick + PDS Line B6	No	1 Double sided heater glued inside each brick box	
Accu Wall P-Box TTCS-P	19.9	26.5	29.5	variable	Kapton Foil	1	Thermostats	No	Glued on the Accu Wall	Ground Test, Control
Accu Wall P-Box TTCS-P	13.4	26.5	29.5	variable	Kapton Foil	1	Thermostats	No	Glued on the Accu Wall	Ground Test, Emergency
Accu Wall S-Box TTCS-P	19.9	26.5	29.5	variable	Kapton Foil	1	Thermostats	No	Glued on the Accu Wall	Ground Test, Control
Accu Wall S-Box TTCS-P	13.4	26.5	29.5	variable	Kapton Foil	1	Thermostats	No	Glued on the Accu Wall	Ground Test, Emergency
Accu Wall S-Box TTCS-S	19.9	26.5	29.5	variable	Kapton Foil	1	Thermostats	No	Glued on the Accu Wall	Ground Test, Control
Accu Wall S-	13.4	26.5	29.5	variable	Kapton	1	Thermostats	No	Glued on the Accu	Ground Test, Emergency

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
Box TTCS-S					Foil				Wall	
Accu Wall S-Box TTCS-S	19.9	26.5	29.5	variable	Kapton Foil	1	Thermostats	No	Glued on the Accu Wall	Ground Test, Control
Accu Wall S-Box TTCS-S	13.4	26.5	29.5	variable	Kapton Foil	1	Thermostats	No	Glued on the Accu Wall	Ground Test, Emergency
Accu Heat Pipe P-Box TTCS-P	20.2	26.5	29.5	variable	Wire	1	Thermostats	No	Soldering onto the Accu heat pipe	Flight Test, Control
Accu Heat Pipe P-Box TTCS-P	13.5	26.5	29.5	variable	Wire	1	Thermostats	No, by analysis	Soldering onto the Accu heat pipe	Flight Test, Emergency
Accu Heat Pipe S-Box TTCS-P	20.2	26.5	29.5	variable	Wire	1	Thermostats	No, by analysis	Soldering onto the Accu heat pipe	Flight Test, Control
Accu Heat Pipe S-Box TTCS-P	13.5	26.5	29.5	variable	Wire	1	Thermostats	No, by analysis	Soldering onto the Accu heat pipe	Flight Test, Emergency
Accu Heat Pipe S-Box TTCS-S	20.2	26.5	29.5	variable	Wire	1	Thermostats	No, by analysis	Soldering onto the Accu heat pipe	Flight Test, Control
Accu Heat Pipe S-Box TTCS-S	13.5	26.5	29.5	variable	Wire	1	Thermostats	No, by analysis	Soldering onto the Accu heat pipe	Flight Test, Emergency
Accu Heat Pipe S-Box TTCS-S	20.2	26.5	29.5	variable	Wire	1	Thermostats	No, by analysis	Soldering onto the Accu heat pipe	Flight Test, Control
Accu Heat Pipe S-Box TTCS-S	13.5	26.5	29.5	variable	Wire	1	Thermostats	No, by analysis	Soldering onto the Accu heat pipe	Flight Test, Emergency
OHP P-Box TTCS-P	44.7	26.5	29.5	-	Wire	1	TTCE Bus A	No, by analysis	Soldering onto the OHP copper structure	Used to drive the OHP experiment
OHP P-Box TTCS-P	44.7	26.5	29.5	-	Wire	1	TTCE Bus B	No, by analysis	Soldering onto the OHP copper structure	Used to drive the OHP experiment
Pre-Heater, TTCS-P	8	26.5	29.5	-	Wire	1	TTCE Bus A	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
Pre-Heater, TTCS-P	8	26.5	29.5	-	Wire	1	TTCE Bus A	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature
Pre-Heater, TTCS-P	8	26.5	29.5	-	Wire	1	TTCE Bus B	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature
Pre-Heater, TTCS-P	8	26.5	29.5	-	Wire	1	TTCE Bus B	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature
Pre-Heater, TTCS-S	8	26.5	29.5	-	Wire	1	TTCE Bus A	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature
Pre-Heater, TTCS-S	8	26.5	29.5	-	Wire	1	TTCE Bus A	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature
Pre-Heater, TTCS-S	8	26.5	29.5	-	Wire	1	TTCE Bus B	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature
Pre-Heater, TTCS-S	8	26.5	29.5	-	Wire	1	TTCE Bus B	No, by analysis	Soldering onto the Pre-heater copper structure	Used to assure that liquid CO2 entering the TTCS evaporator is at saturation temperature
Start-up, TTCS-P	50	26.5	29.5	-	Wire	1	Thermostats	No, by analysis	Soldering onto the Heat Exchangers	Heats CO2 above minimum Tracker switch on temperature
Start-up, TTCS-P	50	26.5	29.5	-	Wire	1	Thermostats	No, by analysis	Soldering onto the Heat Exchangers	Heats CO2 above minimum Tracker switch on temperature
Start-up, TTCS-S	50	26.5	29.5	-	Wire	1	Thermostats	No, by analysis	Soldering onto the Heat Exchangers	Heats CO2 above minimum Tracker switch on temperature
Start-up, TTCS-S	50	26.5	29.5	-	Wire	1	Thermostats	No, by analysis	Soldering onto the Heat Exchangers	Heats CO2 above minimum Tracker switch on temperature

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
Cold Orbit, TTCS-P	54.0	26.5	29.5	-	Wire	1	TTCE Bus A	No, by analysis	Soldering onto the Cold-Orbit copper structure	Prevent freezing in the condenser
Cold Orbit, TTCS-P	54.0	26.5	29.5	-	Wire	1	TTCE Bus B	No, by analysis	Soldering onto the Cold-Orbit copper structure	Prevent freezing in the condenser
Cold Orbit, TTCS-S	54.0	26.5	29.5	-	Wire	1	TTCE Bus A	No, by analysis	Soldering onto the Cold-Orbit copper structure	Prevent freezing in the condenser
Cold Orbit, TTCS-S	54.0	26.5	29.5	-	Wire	1	TTCE Bus B	No, by analysis	Soldering onto the Cold-Orbit copper structure	Prevent freezing in the condenser
TTCS Liquid Lines, RAM P	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus A	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return, and 1*Foil onto condenser plate)	Need to thaw CO2 in TTCS condenser lines after power outage
TTCS Liquid Lines, RAM P	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus B	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return, and 1*Foil onto condenser plate)	Need to thaw CO2 in TTCS condenser lines after power outage
TTCS Liquid Lines, RAM S	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus A	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return, and 1*Foil onto condenser plate)	Need to thaw CO2 in TTCS condenser lines after power outage
TTCS Liquid Lines, RAM S	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus B	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return, and 1*Foil onto condenser plate)	Need to thaw CO2 in TTCS condenser lines after power outage
TTCS Liquid Lines, WAKE P	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus A	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return, and 1*Foil onto condenser plate)	Need to thaw CO2 in TTCS condenser lines after power outage
TTCS Liquid Lines, WAKE P	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus B	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return,	Need to thaw CO2 in TTCS condenser lines after power outage

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
									and 1*Foil onto condenser plate)	
TTCS Liquid Lines, WAKE S	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus A	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return, and 1*Foil onto condenser plate)	Need to thaw CO2 in TTCS condenser lines after power outage
TTCS Liquid Lines, WAKE S	15.6	26.5	29.5	-	14*Wire 1*Foil	15	TTCE Bus B	No, By Analysis	Soldering onto the Capillary Liquid Lines (7*Feed, 7*Return, and 1*Foil onto condenser plate)	Need to thaw CO2 in TTCS condenser lines after power outage
TTCS-P Box heater										Deleted From Design
TTCS-P Box heater										Deleted From Design
TTCS-S Box heater										Deleted From Design
TTCS-S Box heater										Deleted From Design
TRDGB CO2 Tank	10.8	26.5		+39C/+41C	Kapton foil	8	4 thermostats in series + UG-crate A	Yes*	Heaters glued to surface of carbon-fiber overwrapped tank.	*Needed to maintain CO2 above saturation temperature for pressure measurement. Failed "ON" heaters could cause excedence of maximum design temperature (+65C). Failed "OFF" heaters cause no hazard.
TRDGB CO2 Tank	10.8	26.5		+39C/+41C	Kapton foil	8	4 thermostats in series + UG-crate B	Yes*	Heaters glued to surface of carbon-fiber overwrapped tank.	*Needed to maintain CO2 above saturation temperature for pressure measurement. Failed "ON" heaters could cause excedence of maximum design temperature (+65C). Failed "OFF" heaters cause no hazard.

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
TRDGB Xe Tank	7.84	26.5		+26C/+28C	Kapton foil	8	4 thermostats in series + UG-crate A	Yes*	Heaters glued to surface of carbon-fiber overwrapped tank.	*Needed to maintain Xe above saturation temperature for pressure measurement. Failed "ON" heaters could cause excedence of maximum design temperature (+65C). Failed "OFF" heaters cause no hazard.
TRDGB Xe Tank	7.84	26.5		+26C/+28C	Kapton foil	8	4 thermostats in series + UG-crate B	Yes*	Heaters glued to surface of carbon-fiber overwrapped tank.	*Needed to maintain Xe above saturation temperature for pressure measurement. Failed "ON" heaters could cause excedence of maximum design temperature (+65C). Failed "OFF" heaters cause no hazard.
TRDGB Tower Bracket Assy	7.44	26.5		+10C/+15C	Resistors	2	1 thermostat + UG-crate A	No		Needed to maintain valves above operating limit.
TRDGB Tower Bracket Assy	7.44	26.5		+10C/+15C	Resistors	2	1 thermostat + UG-crate B	No		Needed to maintain valves above operating limit.
EBCS, Primary	50 (@120V)	113	126.5	-10C/-3.3C		2	2 thermostats in series per element, Power Line A	No		Maintains EBCS above survival limits. GFE.
EBCS, Secondary	50 (@120V)	113	126.5	-18.3C/-13.3C		2	2 thermostats in series per element, Power Line B	No		Maintains EBCS above survival limits. GFE.
TRD M-Structure, Ram side, Bus A	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range
TRD M-Structure, Ram side, Bus B	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range

AMS-02 THERMAL CONTROL SYSTEM (TCS) HEATER PROPERTIES

Heater String	Power at Min Voltage (W)	Min Voltage (Vdc)	Max Voltage (Vdc)	Set Point	Type	Number of elements	Control	Safety Critical	Mounting	Comments
TRD M-Structure, Wake side, Bus A	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range
TRD M-Structure, Wake side, Bus B	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range
TRD M-Structure, Port side, Bus A	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range
TRD M-Structure, Port side, Bus B	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range
TRD M-Structure, Starboard side, Bus A	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range
TRD M-Structure, Starboard side, Bus B	17,5	113	126,5	+10 C/ +20 C	Resistor	8 resistors in parallel	4 thermostats (two in parallel in series with other two in parallel)	No	Resistors glued to M-Structure	Maintain TRD within “best performace” range