Space
Lightweight and high reliability

Edition 2020

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HUBER+SUHNER

TVAC cable assemblies

Simulating the extreme conditions encountered in space imposes severe requirements on all components, from the test subject inside the thermal vacuum chamber through to the measurement installations on the outside. Exposure to rapid, large-scale thermal gradients within a vacuum environment requires carefully selected materials and designs that can mechanically and electrically withstand these extremes without the risk of multipaction and corona phenomena.

The use of high-power, low-outgassing materials, precision connector designs and innovative manufacturing techniques has allowed HUBER+SUHNER to provide durable, reliable TVAC cable assemblies and connector solutions for our customers within a broad range of TVAC applications.

Features

- In-house thermal aging of components
- Low outgassing materials in accordance with ECSS-Q-ST-70-02 C and NASA reference publication 1124
- Superior mechanical and electrical stability
- Perfectly matched cables and connectors from a single manufacturer
- Cable assemblies and components available for extremely high-power applications

Benefits

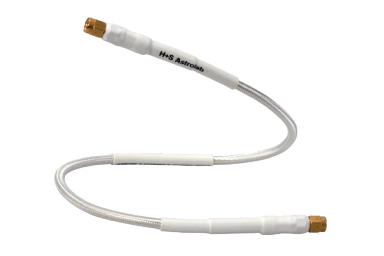
- Vented connectors for fast evacuation
- Longer lifetime, lower costs
- Customized configurations available

SUCOFLEX 100 TVAC – the versatile all-rounder

- Frequency range up to 65 GHz
- Perfectly matched cables and connectors from one manufacturer
- Broad range of cables and connectors available
- Pure jacket and arms for superior flexibility
- Vented connectors
- Armed options available

SUCOFLEX 200 TVAC – the high performance solution

- Frequency range up to 40 GHz
- Ultra low loss: typ. 1 dB/m at 18 GHz
- Fully MIL/DTL–17 qualified
- Extended temperature range

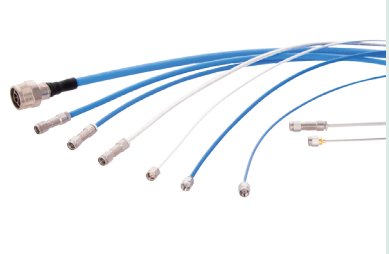


32071 TVAC – for high power applications

- Frequency range up to 14 GHz
- Capable of 500 WCW power handling in an ambient environment of +150 °C and vacuum conditions
- Extensive thermal ageing and stabilisation of the cable assembly is a standard manufacturing process
- Straight TNC, N and SC connectors
- High reliability

Phase stable over temperature raw cables and assemblies

The HUBER+SUHNER CT product family is developed for phase critical applications requiring precision electrical length connectivity. Thus, it creates a stable and reliable interconnect solution to satisfy a huge range of customer applications where phase stability is key. These products provide the industry leading phase vs. temperature performance, as well as a unique range of cable constructions to fulfil any customer TVAC demands.



SUCOFLEX® 100 TVAC

Electrical specifications		
Impedance (nominal)	50 Ω	
Operating frequency	DC – 67 GHz	
Velocity of propagation	77 % | 71 % (SF 167)	
Insertion loss variation vs. temperature	≤ 0.0021 °K–1 ≤ 0.0018 °K–1 (SF 167)	
Return loss (typical)	> 25 dB @ 6 GHz > 21 dB @ 12 GHz > 20 dB @ 18 GHz > 19 dB @ 40 GHz > 16 dB @ 67 GHz	
Capacitance	87 pF*m–1 | 95 pF*m–1 (SF 167)	
Time delay	4.3 ns*m–1 | 4.7 ns*m–1 (SF 167)	

Materials and finishes (according to ASTM-B 298)		
Cable centre conductor	solid silver-plated copper wire P: stranded silver-plated copper wire	
Cable dielectric	low density extruded PTFE	
First outer conductor	helically wrapped silver-plated copper tape	
Second outer conductor	silver-plated copper wire	
Cable jacket	solid extruded FEP	

Cable mechanics		
Minimum bending radius – static	SF 101 11 mm SF 102 12 mm SF 103 13 mm SF 104 16 mm	SF 126 16 mm SF 106 24 mm SF 167 10 mm
Minimum bending radius – dynamic	SF 101 20 mm SF 102 20 mm SF 103 22 mm SF 104 25 mm	SF 126 25 mm SF 106 40 mm SF 167 20 mm

Weight		
SUCOFLEX cable	SF 101 36 g*m–1 SF 102 40 g*m–1 SF 103 53 g*m–1 SF 104 84 g*m–1	SF 126 70 g*m–1 SF 106 157 g*m–1 SF 167 21 g*m–1

Environmental specifications	
Temperature range	–55 to +85/+100/+125 °C depending on connectors and armouring

SUCOFLEX® 200 TVAC

Electrical specifications	
Impedance (nominal)	50 Ω
Operating frequency	DC – 40 GHz
Velocity of propagation	82 %
Insertion loss variation vs. temperature	≤ 0.002 °K–1
Return loss (typical)	> 25 dB @ 6 GHz > 24 dB @ 12 GHz > 23 dB @ 18 GHz > 19 dB @ 40 GHz
Capacitance	81 pF*m–1
Time delay	4.08 ns*m–1

Materials and finishes (according to ASTM-B 298)	
Cable centre conductor	solid silver-plated copper wire
Cable dielectric	low density tape wrapped PTFE
Cable shield	helically wrapped silver plated copper flat wire
Cable braid	solid silver-plated copper wire
Cable jacket	solid extruded FEP

Cable mechanics		
Minimum bending radius	– static	SF 229 23 mm SF 240 8.4 mm
Minimum bending radius	– dynamic	SF 229 70 mm SF 240 25.2 mm

Weight	
SUCOFLEX cable	SF 229 61g*m–1 SF 240 31 g*m–1

Environmental specifications	
Temperature range	–65 to +200 °C

High power 32071 TVAC

- Frequency range up to 14 GHz
- Capable of 500 W CW power handling in an ambient environment of +150 °C and vacuum conditions
- Extensive thermal ageing and stabilisation of the cable assembly is a standard manufacturing process
- Straight TNC, N and SC connectors
- High reliability

Electrical specifications	
Impedance (nominal)	50 Ω
Velocity %	78
Operating frequency	DC – 14 GHz
Insertion loss variation vs. temperature	< 0.0015 °K–6
Return loss (min)	–25 dB @ 2 GHz –27 dB @ 14 GHz
RF leakage	95 dB
Resistance – insulation cable	> 106 MΩ*m
Withstand voltage – cable assembly (at sea level)	> 10 000 V
Capacitance	85.9 pF*m–6
Time delay	4.28 ns*m–6
Phase variation vs. temperature	< 1500 ppm

Materials and finishes	
Cable center conductor	silver plated solid copper
Cable dielectric	tape wrapped PTFE
Cable shield	silver plated copper helical foil
Cable binder	silver plated flat copperwire braid
Cable jacket	extruded FEP

Cable mechanics	
Diameter	9.40 mm
Minimum bending radius – static	50.8 mm
Minimum bending radius – dynamic	152.4 mm
Cable retention force on ruggedized cable assemblies	135 N
Weight	208.4 g*m–1

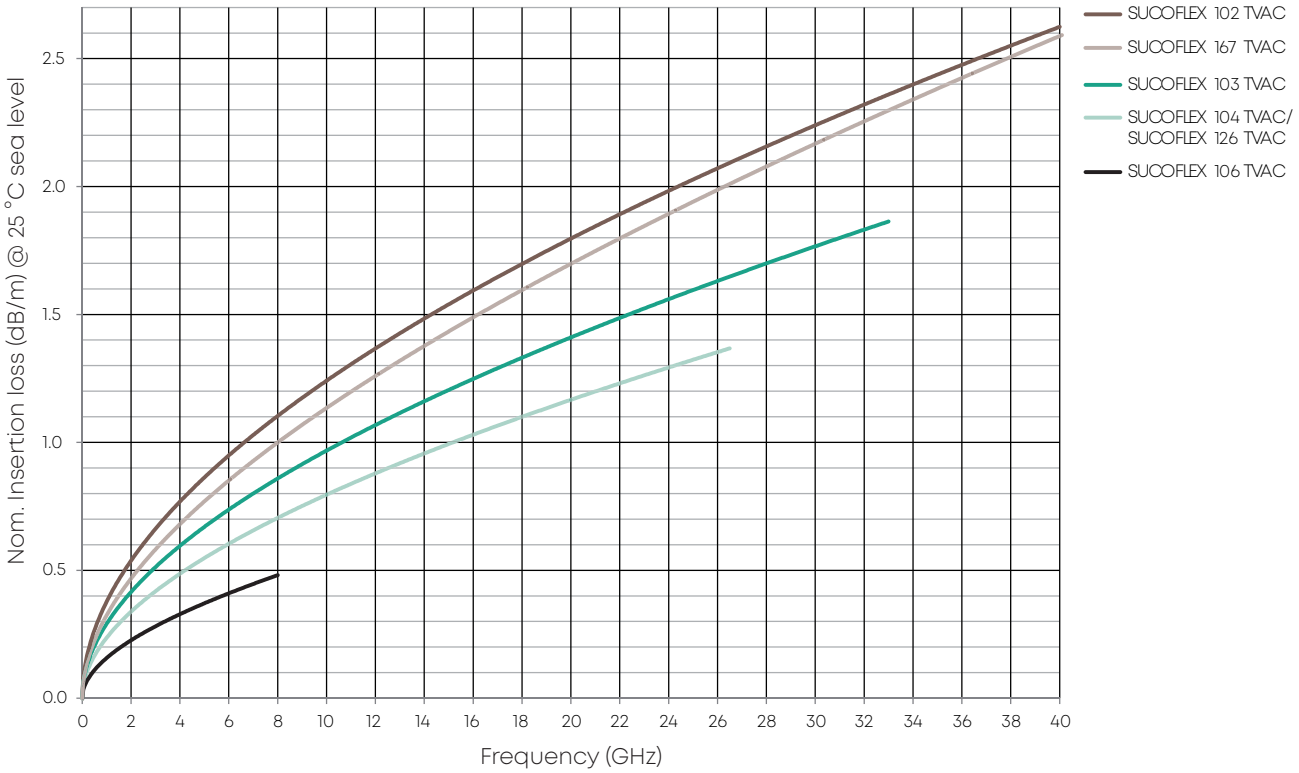
Environmental specifications	
Temperature range	–55 to +200°C
Radiation resistance	30 Mrad
Out gassing according ECSS-Q-ST-70-02 and NASA reference publication 1124	TML < 1 %, CVCM < 0.1 %

SUCOFLEX® TVAC – portfolio

Assembly type	Freq. range	Connectors	Temperature range	Special benefit
SUCOFLEX 102 TVAC	DC – 40 GHz	11_SK-263_TVAC (2.92)	–55 to +125°C	
SUCOFLEX 103 E TVAC	DC – 33 GHz	11_SK-312_TVAC (2.92)	–40 to +85 °C	flexible jacket
SUCOFLEX 103EA TVAC	DC – 33 GHz	11_SK-312_TVAC (2.92)	–40 to +85 °C	armour type A
SUCOFLEX 104 TVAC	DC – 18 GHz	11_SMA-454_TVAC	–55 to +125 °C	
	DC – 26.5 GHz	11_PC35-411_TVAC (3.5)	–55 to +125 °C	
	DC - 18GHz	11_TNC_476_TVAC	–55 to +125 °C	
SUCOFLEX 104E TVAC	DC – 18 GHz	11_SMA-454_TVAC	–40 to +85 °C	flexible jacket
	DC – 26.5 GHz	11_PC35-411_TVAC (3.5)	–40o +85 °C	
	DC - 18GHz	11_TNC_476_TVAC	–40 to +85 °C	
SUCOFLEX 104EA TVAC	DC – 18 GHz	11_SMA-454_TVAC	–40 to +85 °C	armour type A flexible jacket
	DC – 26.5 GHz	11_PC35-411_TVAC (3.5)	–40 to +85 °C	
	DC - 18GHz	11_TNC_476_TVAC	–55 to +85 °C	
SUCOFLEX 126 TVAC	DC – 18 GHz	11_SMA-454_TVAC	–55 to +125 °C	stranded center conductor
	DC – 26.5 GHz	11_PC35-411_TVAC (3.5)	–55 to +125 °C	
	DC - 18GHz	11_TNC_476_TVAC	–55 to +125 °C	
SUCOFLEX 126E	DC – 18 GHz	11_SMA-454_TVAC	–40 to +85 °C	flexible jacket stranded center conductor
	DC – 26.5 GHz	11_PC35-411_TVAC (3.5)	–40 to +85 °C	
	DC - 18GHz	11_TNC_476_TVAC	–40 to +125 °C	
SUCOFLEX 126EA	DC – 18 GHz	11_SMA-454_TVAC	–40 to +85 °C	armour type A stranded center conductor
	DC – 26.5 GHz	11_PC35-411_TVAC (3.5)	–40 to +85 °C	
	DC - 18GHz	11_TNC_476_TVAC	–40 to +85 °C	
SUCOFLEX 167 TVAC	DC – 67 GHz	11-PC185-27 (1.85)	–55 to +165 °C	
SUCOFLEX 229 TVAC	DC – 29 GHz	SMA 26.5 SK (2.92) TNC N	–65 to +200°C	phase stable low insertion loss
SUCOFLEX 240 TVAC	DC – 40 GHz	SMA SK (2.92)	–65 to +200 °C	phase stable low insertion loss
32071 TVAC	DC – 14 GHz	TNC, SC	–70 to +200 °C	see power handling
MULTIFLEX_141_CT	DC – 33 GHz	SK (2.92) SMA	–65 to +200 °C	phase stable
MULTIFLEX_210_CT	DC – 30 GHz	SK (2.92) SMA	–65 to +200 °C	phase stable
MULTIFLEX_318_CT	DC – 18 GHz	N TNC	–65 to +200 °C	phase stable

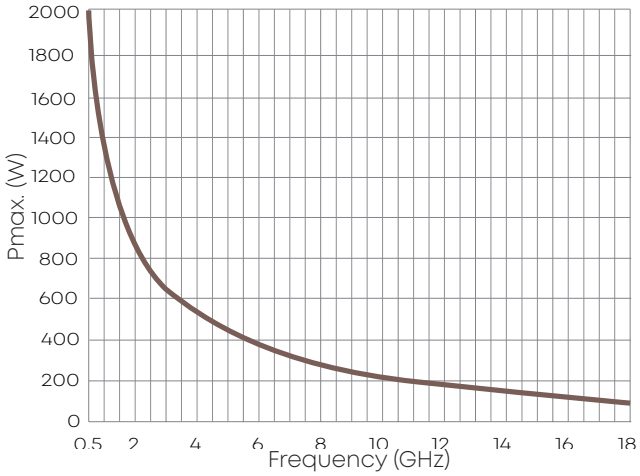
SUCOFLEX® 100 – series TVAC

Insertion loss vs. frequency



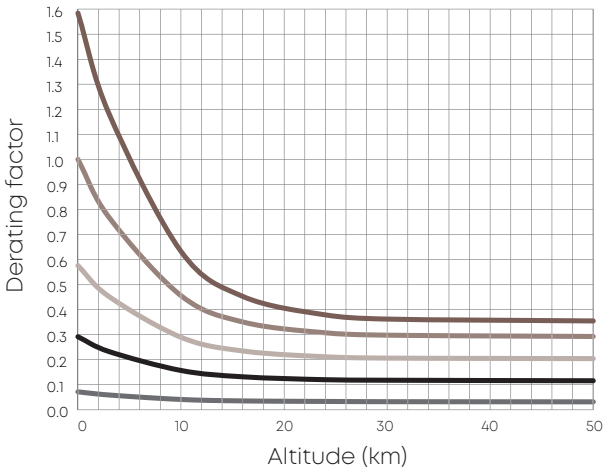
CW power SUCOFLEX® 126 TVAC with TNC connectors

CW power max. vs. frequency



SUCOFLEX 126 TVAC with TNC connectors

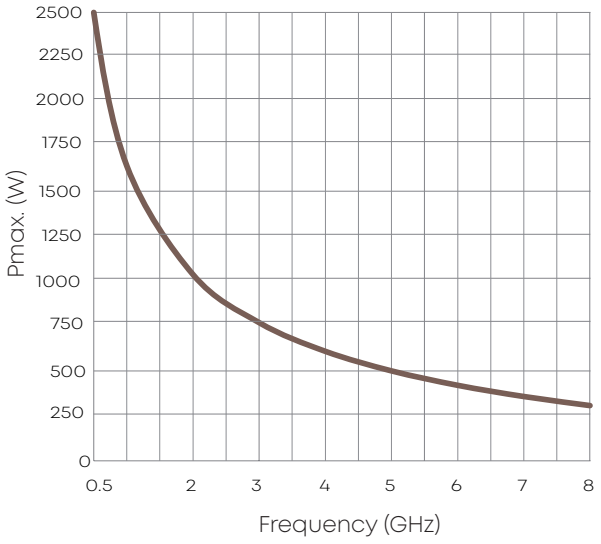
Derating factor



T = –55 °C
T = 25 °C
T = 85 °C
T = 125 °C
T = 155 °C

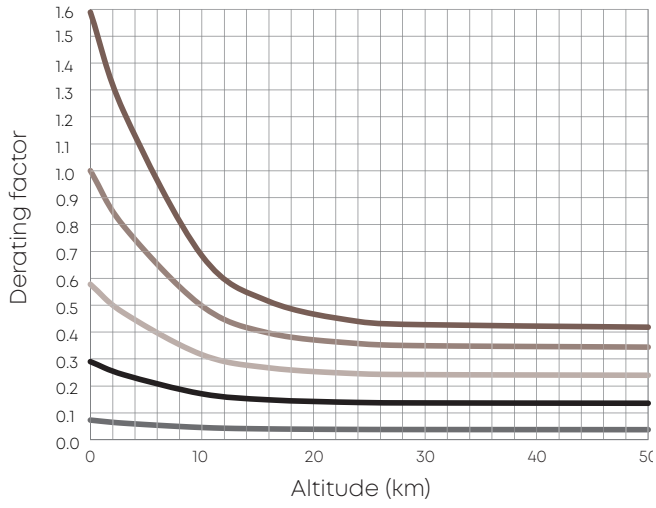
CW power SUCOFLEX® 106 TVAC with TNC connectors

CW power max. vs. frequency



SUCOFLEX 106 TVAC with TNC connectors

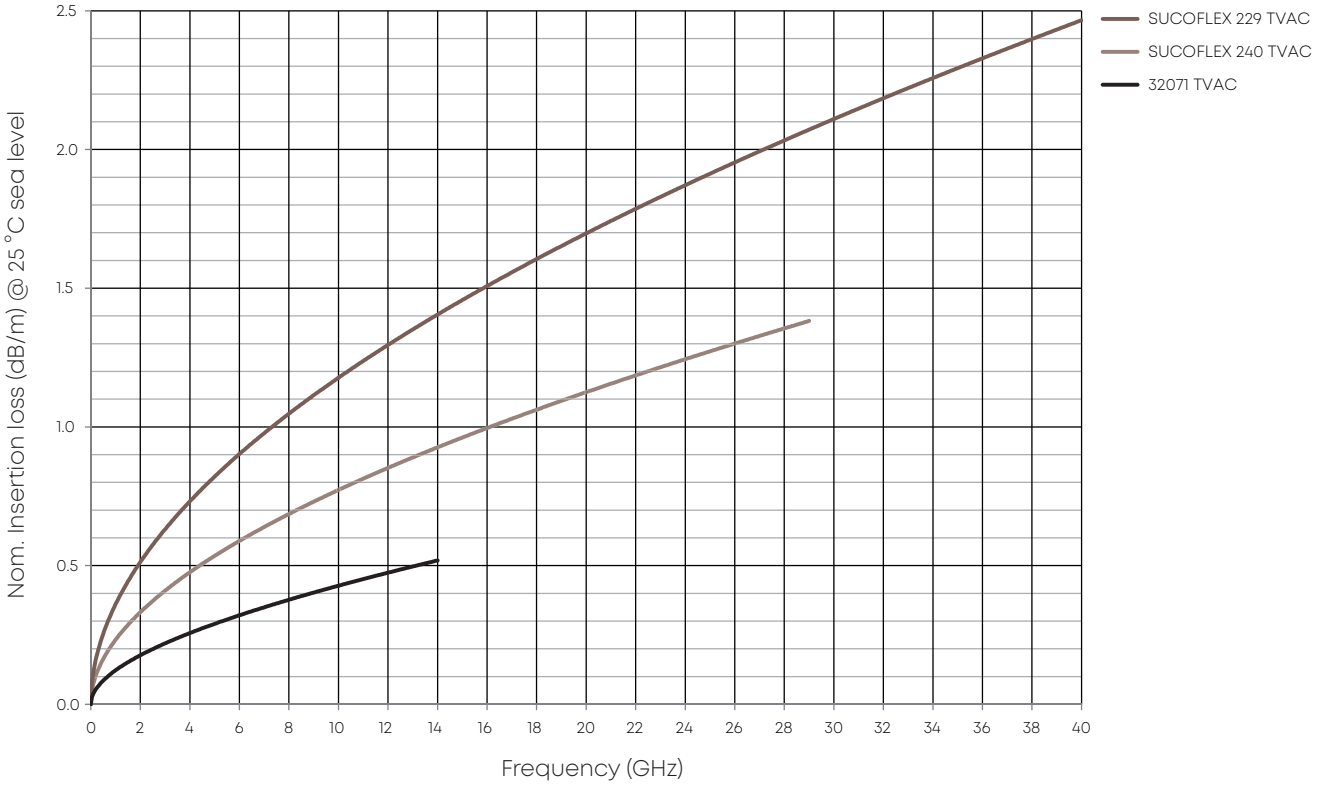
Derating factor



T = –55 °C
T = 25 °C
T = 85 °C
T = 125 °C
T = 155 °C

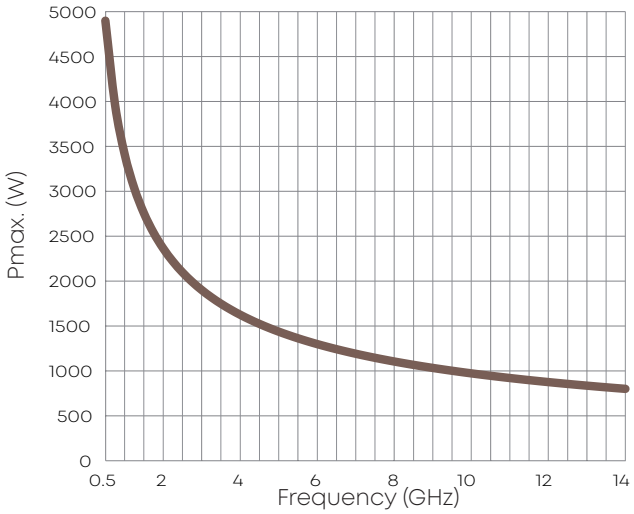
SUCOFLEX® 200 TVAC series and 32071 TVAC

Insertion loss vs. frequency



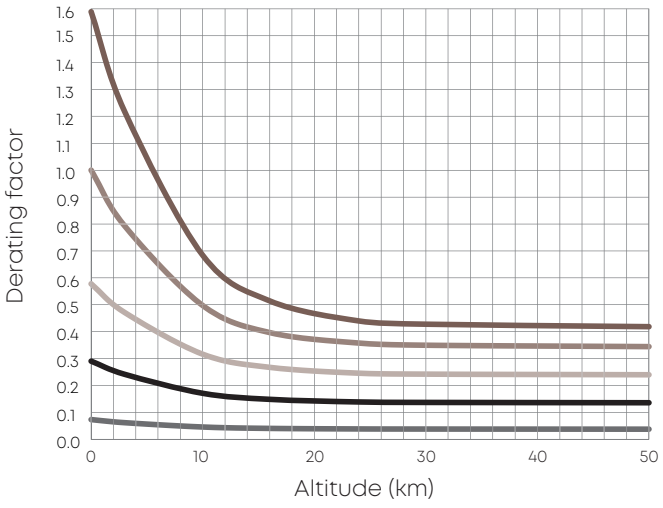
CW power 32071 with TNC connectors

CW power max. vs. frequency



32071 TVAC with TNC connectors

Derating factor



T = −55 °C
T = 25 °C
T = 85 °C
T = 125 °C
T = 155 °C

Thermal vacuum hermetic sealed adaptors

HUBER+SUHNER offers a wide array of hermetic feed-thru style adaptors that offer both in-series and between series interface solutions for TVAC testing applications. The hermeticity is provided through a glass-fired seal within the adaptor body. The glass material is selected to provide the best electrical performance while also matching the coefficient of thermal expansion of the surrounding body and contact as closely as possible to prevent any loss of hermeticity. All of the hermetic adaptors are 100 % tested for hermeticity in accordance with ASTM E-498, MIL-STD-202, and MIL-STD-883. The guaranteed leakage rate is less than 1 X 10E-8 ccm/second of helium under a pressure differential of 15 psig (1 bar).

2.9 mm jack – 2.9 mm jack, jack hermetic/29485G-4		
Impedance	nominal	50 Ω
Frequency	max.	40 GHz
Insertion loss	max.	1.00 dB
VSWR	max.	1.50 : 1
Temperature range		–55 to +125 °C
Standard		MIL-STD-348
Hermetic seal		ASTM E-498, MIL-STD-202 and MIL-STD-883

TNC jack – TNC jack, bulkhead, hermetic/29396G-1		
Impedance	nominal	50 Ω
Frequency	max.	10 GHz
Insertion loss	max.	0.60 dB
VSWR	max.	1.35 : 1
Temperature range		–55 to +125 °C
Standard		MIL-STD-348
Hermetic seal		ASTM E-498, MIL-STD-202 and MIL-STD-883

N jack – N jack, bulkhead, hermetic/29304G		
Impedance	nominal	50 Ω
Frequency	max.	11 GHz
Insertion loss	max.	0.80 dB
VSWR	max.	1.20 : 1
Temperature range		–55 to +125 °C
Standard		MIL-STD-348
Hermetic seal		ASTM E-498, MIL-STD-202 and MIL-STD-883

Thermal vacuum hermetic sealed adaptors

SMA jack – SMA jack, bulkhead, hermetic/29285G		
Impedance	nominal	50 Ω
Frequency	max.	22 GHz
Insertion loss	max.	0.55 dB
VSWR	max.	1.30 : 1 (10 GHz)/1.45 : 1 (22 GHz)
Temperature range		–55 to +125 °C
Standard		MIL-STD-348
Hermetic seal		MIL-STD-202, MIL-STD-883 and ASTM E-498

SMA jack – N jack, hermetic/29033-0G		
Impedance	nominal	50 Ω
Frequency	max.	8 GHz
Insertion loss	max.	0.35 dB
VSWR	max.	1.25 : 1
Temperature range		–55 to +125 °C
Standard		MIL-STD-348
Hermetic seal		MIL-STD-202, MIL-STD-883 and ASTM E-498

SMA jack – TNC jack, bulkhead, hermetic/29003-0-3G		
Impedance	nominal	50 Ω
Frequency	max.	10 GHz
Insertion loss	max.	0.35 dB
VSWR	max.	1.20 : 1
Temperature range		–55 to +125 °C
Standard		MIL-STD-348
Hermetic seal		MIL-STD-202, MIL-STD-883 and ASTM E-498

Space flight phase shifters

The phase shifter product family is designed for use in electronic systems where precision adjustment and tuning of transmission line electrical lengths are required. The phase shifter, or line trimmer, is designed to allow precise in-line phase change while maintaining constant VSWR and Insertion Loss performance values. The construction of the phase shifters incorporates fine gauge threads for precise tuning accuracy at a resolution of less than 0.1 degrees. A variety of interfaces and phase adjustment ranges are available with operation up to 26 GHz. These passive devices have proven successful in aerospace and satellite programs with flight heritage in both North America and Europe.

Type	Interfaces		Frequency range (GHz)		Total ΔΦ		VSWR		Dimension (mm)		Dimension (inch)	
	1	2	min	max.	min	max.	min	max.	closed	open	closed	open
40002C	SMA plug	SMA plug	0.1	4.0	4°	160°	1.05:1	1.28:1	108.71	143.00	4.28	5.63
40003C	SMA plug	SMA jack	0.1	4.0	4°	160°	1.05:1	1.28:1	105.66	139.95	4.16	5.51
40004C	SMA jack	SMA jack	0.1	4.0	4°	160°	1.05:1	1.28:1	103.38	137.67	4.07	5.42
40019C	N plug	TNC jack	0.1	4.0	4°	160°	1.15:1	1.35:1	117.86	152.15	4.64	5.99
40020C	TNC jack	TNC jack	0.1	4.0	4°	160°	1.15:1	1.35:1	129.79	164.08	5.11	6.46
40002A	SMA plug	SMA plug	0.5	8.0	35°	570°	1.08:1	1.25:1	159.00	218.44	6.26	8.60
40003A	SMA plug	SMA jack	0.5	8.0	35°	570°	1.08:1	1.25:1	155.96	215.39	6.14	8.48
40004A	SMA jack	SMA jack	0.5	8.0	35°	570°	1.08:1	1.25:1	153.67	213.11	6.05	8.39
40006A	N plug	N jack	0.5	8.0	33°	538°	1.08:1	1.25:1	164.34	220.47	6.47	8.68
40007A	N jack	N jack	0.5	8.0	33°	538°	1.08:1	1.25:1	163.07	219.20	6.42	8.63
40002B	SMA plug	SMA plug	8.0	18.0	97°	219°	1.25:1	1.40:1	58.42	68.58	2.30	2.70
40003B	SMA plug	SMA jack	8.0	18.0	97°	219°	1.25:1	1.40:1	53.37	65.58	2.18	2.58
40004B	SMA jack	SMA jack	8.0	18.0	97°	219°	1.25:1	1.40:1	52.07	62.23	2.05	2.45
40005B	N plug	N plug	8.0	18.0	102°	230°	1.25:1	1.40:1	73.91	84.58	2.91	3.33
40006B	N plug	N jack	8.0	18.0	102°	230°	1.25:1	1.40:1	73.15	83.82	2.88	3.30
40007B	N jack	N jack	8.0	18.0	102°	230°	1.25:1	1.40:1	68.83	79.50	2.71	3.13
40011B	N jack	SMA plug	8.0	18.0	92°	208°	1.25:1	1.40:1	60.71	70.36	2.39	2.77
40004D	SMA jack	SMA jack	8.0	26.0	146°	474°	1.25:1	1.37:1	56.90	72.90	2.24	2.87
40004E	SMA jack	SMA jack	8.0	26.0	146°	474°	1.25:1	1.37:1	56.90	72.90	2.24	2.87

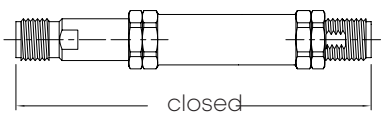
Environmental qualification levels:

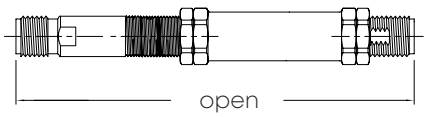
Thermal shock: MIL-STD-202, Method 107, 100 cycles, –55/+125 °C

Sine vibration: MIL-STD-202, Method 204, 21 g peak

Random vibration: MIL-STD-202, Method 214, 26.1 g rms

Mechanical shock: MIL-STD-202, Method 213, 750 g peak.





32071 high power cable assemblies

The 32071 cable assembly offers incredible benefits to not only withstand extreme temperature and high altitude conditions, but also provide outstanding performance at high power levels. Based on its Fluoroloy® loaded connectors we can guarantee up to 500 W CW power at 150 °C under vacuum.
In addition, HUBER+SUHNER provides a comprehensive array of Fluoroloy® loaded panel connectors and feed-throughs for high power applications. Fluoroloy® has a higher dielectric constant (as compared to standard Teflon dielectric), but also a higher rate of thermal conductivity. This provides a more effective and efficient transfer of the heat generated at the center conductor, thus increasing the power handling capability of the connector. Fluoroloy® dielectric is available as an option on all of our connector types, should the power levels of the application require it.

32071 – high power, low loss

Product description

Boa-flex II cables utilize a microporous PTFE dielectric for low loss with minimal phase change due to temperature changes and flexure. Typical velocity is 78 % of the speed of light. All offer very low loss and are extremely stable with flexure.

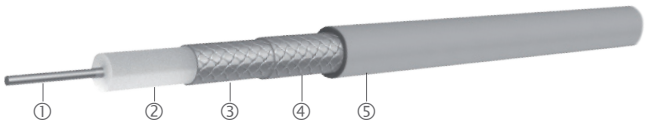
Product features

- Impedance 50 Ω
- Applicable up to 14 GHz
- Low density PTFE for superior electrical performance
- Helical wrapped outer conductor for increased electrical performance
- Exceptional phase and insertion loss stability with flexure
- Excellent phase vs. temperature characteristics
- Preferred for phase matching and tracking applications

Recommended connectors

32071	TNC, N, SC
	Others available

Construction



Cable	Inner conductor ①	Dielectric ②	Outer conductor ③	Outer braid ④	Jacket ⑤	Outer diameter
						mm
32071	CuAg solid	PTFE microporous	CuAg tape	CuAg	FEP, translucent amber	9.5

Technical data

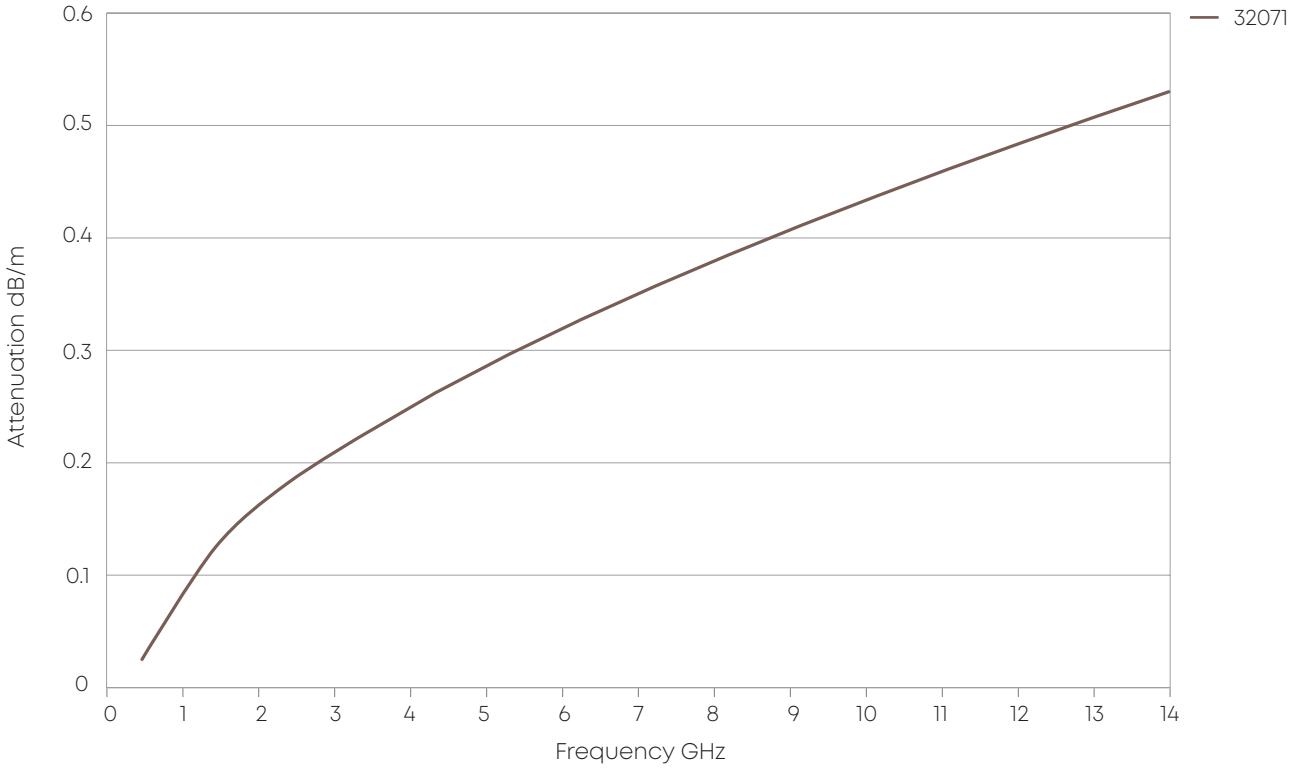
Cable	Item no.	Max. operating frequency	Velocity of propagation	Weight	Min. bending radius		Temperature range
		GHz	%	g/m	static mm	dynamic mm	°C
32071	80310956	14	78	208.3	50.8	152.4	−55 to +200

Available connectors

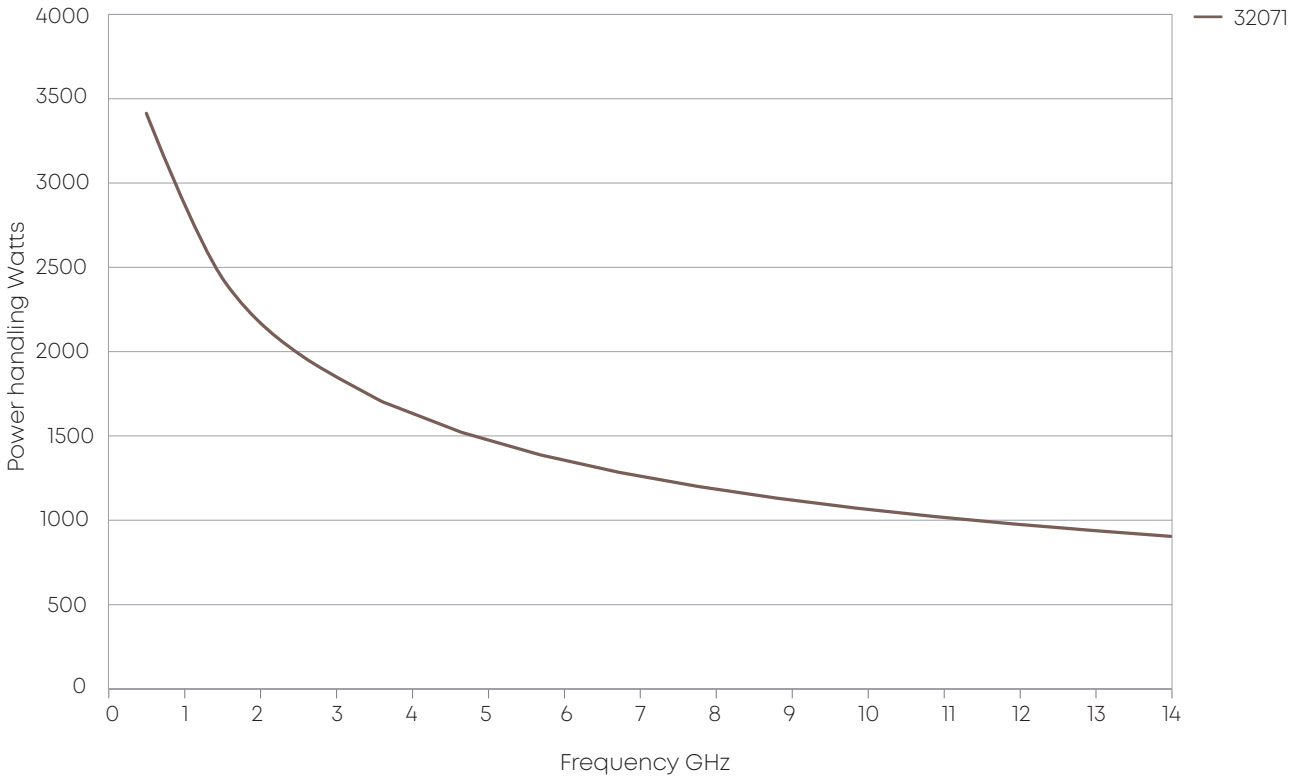
Connector	Series, pattern	HUBER+SUHNER type	Cable	Operating frequency	Item no.
				GHz	
TNC	straight cable plug	29614-32-71	32071	12.4	80318585
	straighthighpowercableplug	29614FLPV3-32-71		4.8	80378457
	straight vented cable plug	29614HTPV-32-71		12.4	80378181
N	straight cable plug	29602-32-71		12.4	80318491
	straight cable jack	29601-32-71		12.4	80318466
	straight bulkhead cable jack	29636-32-71		12.4	80340623
SC	straight cable plug	29608-32-71		10.0	80318547

32071 – graphs

Attenuation (nominal values at +25 °C ambient temperature)



Power handling (maximum values at 25 °C ambient temperature and sea level)



32071 – high power connectors and adaptors

29396G3-ELPV

- Hermetic TNC jack to TNC jack bulkhead adaptor
- Positively vented and pre-potted
- Frequency range up to 10 GHz
- Designed for high power and multipaction-free applications

29713-46ELPV

- Panel mount TNC jack connector
- Integrated heat sink for high power handling capability
- Positively vented and pre-potted
- Frequency range up to 14 GHz
- Designed for high power and multipaction-free applications