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British Standard: Aerospace Series Specification for

Preformed corrosion-resisting steel wire rope (ISO diameters and strengths)

Foreword

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31st March 2014.

BS W 13:1973+A1:2014 supersedes BS W 13:1973, which is withdrawn.

Text introduced or altered by Amendment No. 1 is indicated in the text by tags A1 A1. Minor editorial changes are not tagged.

This British Standard specifies requirements for preformed corrosion-resisting steel wire rope conforming to BS ISO 2020-1, *Aerospace – preformed flexible steel wire rope for aircraft controls – Part 1: Dimensions and loads* and BS ISO 2020-2:1997, Aerospace – Preformed flexible steel wire rope for aircraft controls – Part 2: Technical specification.

BS ISO 2020-1 specifies diameter, construction and minimum breaking strength of the rope, all of which are in accordance with Recommendation No. 3310 of l'Association Internationale des Constructeurs de Material Aerospatiale (A.I.C.M.A.) and with the United States Military Specification MIL-DTL-83420M. Size of rope, larger than 6.4 mm (¼ in) diameter, though included in MIL-DTL-83420M, are seldom used in modern aircraft, and have been omitted from this standard.

The nominal size of rope is now expressed in terms of diameter rather than of minimum breaking strength (in hundredweights) as in earlier British Standards for aircraft wire rope. Construction is of 7 × 7 or 7 × 19 according to size, 7 × 14 being no longer used. The strength/weight ratio of the new rope is higher than that in the previous standards but a direct comparison is not possible because of the change in the method of expressing the nominal size.

In order to meet the severe conditions in which wire rope operates in the control systems of modern aircraft, some aspects are more fully specified than in earlier standards. In Section **2** the composition of the wire, examined for compliance with the general requirements of BS 6S 100:2010, is now specified. Dimensional tolerances for the wire and grade of tensile strength are also given.

Section **3** of the specification, which deals with the manufacture of the rope, specifies the construction in greater detail than in earlier standards and introduces limits for length of lay. An internal lubricant is added with the aim of achieving a longer life. An elongation test is included to establish that the elongation is within specified limits at stated increments of load.

Reference is made in this British Standard to the latest issue of the following:

BS A 4, *Test pieces and test methods of metallic materials for aircraft – Metric units*
BS EN 10264-4, *Steel wire and wire products – Steel wire for ropes – Part 4: Stainless steel wire*
BS ISO 2020-1, *Aerospace – Preformed flexible steel wire rope for aircraft controls – Part 1: Dimensions and loads*
Def Stan 01-5, *Fuels, lubricants and associated products*
Def Stan 91-51, *Grease, aircraft: helicopter oscillating Bearing NATO code: G-366, Joint service designation: XG-284*
and the following standards at the edition shown
BS 6S 100:2010, *Aerospace series – Procedure for inspection, testing and acceptance of wrought steels (other than plate, sheet strip and tube)*
BS ISO 2020-2:1997, *Aerospace – Preformed flexible steel wire rope for aircraft controls – Part 2: Technical specification*

Other British Standards in this series for wire ropes are:

BS W 9 Preformed galvanized carbon steel wire rope.
BS W 11 Preformed corrosion-resisting steel wire rope.
BS W 12 Preformed galvanized carbon steel wire rope (ISO diameters and strengths).

Information on SI units is given in BS ISO 80000-1, *Quantities and units – Part 1: General* and BS 350, *'Conversion factors for units'*, to which reference should be made when required.

1. General

1.1 Scope

[A1] This British Standard specifies requirements for preformed corrosion-resisting steel wire rope in accordance with BS ISO 2020-1 and BS ISO 2020-2. [A1]

The standard is in three sections, the first covering scope and definitions, the second the properties of the wire from which the rope is made, and the third the dimensions, construction and testing of the wire rope.

An appendix to the standard outlines the precautions which should be taken during handling of wire rope.

1.2 Definitions*

For the purposes of this British Standard the following definitions apply:

(1) *Wire.* Each cylindrical steel element.

(2) *Strand.* An element of rope consisting of an assembly of several wires of appropriate shape and dimensions spun helically in one or more layers.

(3) *Wire rope.* A construction of several strands wound helically in one or more layers.

(4) *Preforming.* The process by which the wires in the strand, and the strands in the rope, are formed during rope manufacture into the shape that they will assume in the finished rope.

(5) *Nominal diameter.* The value by which the diameter of the wire, strand or rope is designated.

(6) *Measured diameter.* That diameter which is obtained by measuring in accordance with a prescribed method (see 3.2.2).

(7) *Length of lay.* The pitch of the helix of the axis of the strand (or wire) in the longitudinal axis of the rope (or strand).

(8) *Core wire (king wire).* The centre wire of each strand.

(9) *Centre or core strand (of a wire rope).* A straight strand composed of wires as for the other strands.

(10) *Elongation.* That length by which the rope extends between defined upper and lower limits of load (i.e. between first and second reading), expressed as a percentage of the gauge length measured at the lower limit.

2. Corrosion resisting steel wire for the manufacture of wire rope

2.1 Steel quality

2.1.1 Chemical composition. The cast analysis shall conform to the following limits.

	%	
	Min.	**Max.**
Carbon	—	0.12
Silicon	0.20	1.00
Manganese	0.5	2.00
Phosphorus	—	0.045
Sulphur	—	0.030
Chromium	17.00	19.00
Nickel	8.0	11.00

[A1] NOTE The nearest equivalent steel is X5CrNi18-10 (1.4301) to BS EN 10264-4. [A1]

* The definitions given relate only to this standard but where appropriate are in accordance with [A1] ISO 2532 [A1]. *'Steel wire ropes vocabulary'.*

2.1.2 The steel shall comply with the general requirements of Section **1** of British Standard 6S 100:2010.

2.1.3 The steel shall be manufactured by an electric process.

2.1.4 The complete analysis of every cast shall be supplied to the inspector.

2.1.5 The ingots, blooms or billets shall be overall dressed in accordance with [A1] **11.1** of BS 6S 100:2010 [A1].

2.1.6 For deep etch tests, samples shall be taken in accordance with [A1] **14** [A1] of [A1] BS 6S 100:2010 [A1].

2.2 Rods

2.2.1 Rods for wire shall be made from billets complying with **2.1.**

2.2.2 The rods shall be examined visually for signs of surface imperfections and shall be free from harmful defects. In addition a 200 mm length shall be cut from each end of each coil and shall be subjected to a deep etch test.

Test samples shall be immersed in either:

(1) A solution containing 10 % by volume of concentrated nitric acid and 3½ % by volume of hydrofluoric acid (40 % HF) in water at 60 °C for not less than 10 nor more than 15 minutes.

(2) Any alternative solution approved by the Inspecting Authority.

If any sample from a coil exhibits harmful defects after this test, the coil from which the sample was taken shall be rejected but may be re-submitted for deep etch testing after suitable cropping by the manufacturer.

2.2.3 Susceptibility to intercrystalline corrosion. A test piece shall be selected to represent each coil and shall be immersed for 72 hours in a boiling solution having the following composition:

111 g copper sulphate ($CuSO_4.5H_2O$)

98 g sulphuric acid (S.G. 1.84)
made up to 1 litre with distilled water.

Precautions shall be taken during boiling to prevent concentration due to evaporation. Each test piece shall be dropped on a metal or stone surface, and shall emit a clear metallic ring. The test piece shall then be bent through an angle of 90 ° over a radius of three times its diameter and shall withstand this treatment without cracking.

2.3 Wire manufacture

2.3.1 Condition. The wire shall be made from rods complying with **2.2** and shall be supplied in the cold drawn condition with no subsequent heat treatment.

2.3.2 Surface finish and freedom from defects. The wire shall be examined visually for signs of surface imperfections, and shall be free from harmful defects. The standard of surface finish shall be agreed between the manufacturer and the purchaser and stated on the order.

2.4 Size tolerences

2.4.1 Tolerance. The tolerance on the diameter of the wire shall not exceed that given in the table below. The cross section shall be circular to within half the given tolerances:

Nominal wire diameter		Tolerance
From	Up to and including	
mm	mm	mm
0.20	0.25	± 0.005
0.25	0.375	± 0.008
0.375	0.475	± 0.010
0.475	0.60	± 0.013

2.4.2 Diameter of wire. The diameter shall be taken as the mean of two micrometer measurements made at right angles to each other on a straight piece of wire. Individual measurements shall lie within the diameter tolerance.

2.5 Samples for tests

The inspector shall select from each end of each coil of finished wire a test sample of sufficient length to provide for each of the tests required by **2.6, 2.7** and **2.8.**

2.6 Tensile strength test

2.6.1 A tensile strength test shall be made on a portion of each sample in accordance with [A1] BS 4 A 4 [A1].

2.6.2 The tensile strength of the wire shall be calculated on the nominal diameter.

2.6.3 The tensile strength of the wire shall be not less than that given below for the appropriate nominal wire diameter. The variation in tensile strength of all the wires in any one layer of the rope shall be not greater than 295 N/mm^2.

Nominal wire diameter		Minimum tensile strength
From	Up to but not including	
mm	mm	N/mm^2
0.10	0.20	2060
0.20	0.25	1960
0.25	0.30	1865
0.35	0.40	1815
0.40	0.50	1765
0.50	0.60	1715

NOTE. King wires may be of a lower tensile grade and strength range but shall comply with this standard in every other respect. (See **3.5.1.2**).

2.7 Ductility wrap test

A portion of each sample shall be wrapped for eight complete close turns around a mandrel having a diameter equal to the wire diameter, and unwrapped seven turns without fracture.

2.8 Test for intercrystalline corrosion

A portion of each sample shall be subjected to the test specified in **2.2.3** omitting the ringing portion of the test.

2.9 Re-tests

Should any test piece fail to meet the test requirements, two further test pieces in respect of each failure shall, if the wire manufacturer so desires, be cut from the same end of the coil of wire from which the failed test piece was cut, and shall be subjected to the tests in **2.6** to **2.8.** If both the additional test pieces fulfil the test requirements, the coil shall be accepted but if either fail the coil shall be deemed not to comply with this standard.

2.10 Identification

Each coil of wire passed by the inspector shall have securely attached a durable tally or label marked with:

(1) The manufacturer's name or identification mark.

(2) The mark of the inspector.

(3) The number of this British Standard , i.e. BS W 13.

(4) The coil number.

(5) The nominal size and specified tensile range of the wire.

(6) The release note number and customer's order number.

3. Preformed corrosion-resisting steel wire rope

3.1 Material

3.1.1 The wire used in the manufacture of preformed corrosion-resisting steel wire ropes shall comply with the requirements of **2.3.**

3.1.2 The wire rope manufacturer shall specify to the wire manufacturer the required tensile strength range of the wire (see **2.6.3** and **3.5.1.2**).

3.2 Size

3.2.1 Nominal diameter. The designation of a wire rope shall be in terms of its nominal diameter and shall be one of those listed in Table 1, Column 1.

3.2.2 Measured diameter

3.2.2.1 The actual diameter of a rope shall be measured with a suitable caliper which possesses jaws broad enough to cover not less .than two adjacent strands (see Fig. 1).

3.2.2.2 The measurements shall be taken at two points spaced at least one metre apart and at each of these points two diameter measurements shall be taken, the one at right angles to the other. The average of these four measurements shall fall within the maximum and minimum diameters given in Table 1, Columns 3 and 4.

3.2.2.3 The actual diameter of ropes shall be measured on a straight portion of the rope under no tension.

3.2.2.4 Each end of each manufactured length of wire rope shall be measured in this manner.

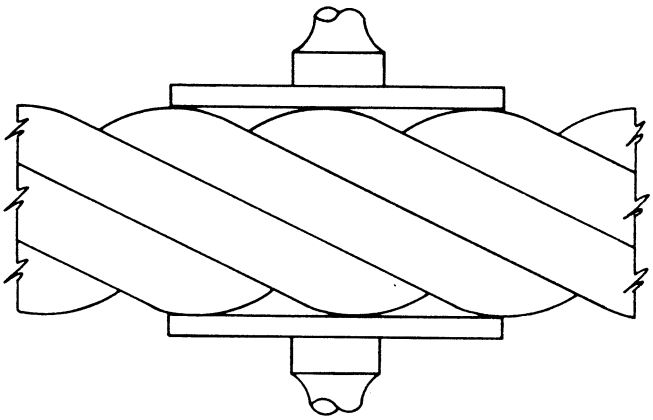

Fig. 1. Method of measuring rope diameter

3.3 Weight

The maximum weight per unit length of wire rope for a particular size shall not exceed that listed in Table 1, Column 7.

3.4 Length

The length of a piece of wire rope after samples for testing have been removed shall be not shorter, nor more than 5 % longer, than the length ordered. Ropes shall be delivered in minimum lengths of 300 m, except that up to 20 % of the rope ordered may be furnished in lengths between 150 m and 300 m.

3.5 Construction

3.5.1 General. Wire ropes covered by this British Standard shall conform to one of the types of construction listed in Table 1, Column 2.

3.5.1.1 The core strand of the rope shall be of sufficient size and density to give full support to the strands. The size of the core shall exceed that of each outer strand.

3.5.1.2 The core or king wire of strands may be of different tensile grade from the outer wires, and shall be of sufficient size to give full support to the outer wires.

3.5.2 7 x 7 construction. This shall be composed of six outer strands, each of seven wires spun in a right hand direction around a core strand of seven wires.

3.5.2.1 The core strand shall be composed of a layer of six wires spun in a right hand direction around a core or king wire.

3.5.2.2 The six outer strands shall be composed of six wires spun in a left hand direction around a core or king wire.

3.5.3 7 x 19 construction. This shall be composed of six strands of nineteen wires spun in a right hand direction around a core strand of nineteen wires.

3.5.3.1 The core strand shall be composed of a first layer of six wires spun in a left or right hand direction around a core or king wire and a second layer of twelve wires spun in a right hand direction.

3.5.3.2 The six outer strands shall be composed of a first layer of six wires and a second layer of 12 wires spun in a left hand direction around a core or king wire.

3.5.4 Length of lay. The length of lay of ropes shall be between six and eight times the diameter of the rope.

3.5.4.1 *Length of lay of wires in strands for ropes of 7 x 7 construction.* The length of lay of wires spun around the core wire shall be less than 60 % of the length of lay of the rope.

3.5.4.2 *Length of lay of wires in strands for ropes of 7 x 19 construction.* The length of lay of the six inner wires spun around the core wire shall be less than 60 % of the length of lay of the twelve outer wires. The length of lay of the twelve outer wires around the seven inner wires shall be less than 50 % of the length of lay of the rope.

3.5.5 Preforming. The rope shall be preformed during manufacture in such a manner that the finished wire rope satisfies the test specified in **3.8.6.**

3.5.6 Joints. When it is necessary to introduce new lengths of wire the joints shall be distributed as far apart as possible. The ends shall be tucked in, and in no case shall more than one joint occur in a length of 6 m of strand. For wire of 0.20 mm diameter or less twisted joints may be made. For wire of diameter greater than 0.20 mm, joints should be made by electric welding or brazing.

3.5.7 Defects. Each length of finished rope shall be of uniform lay and shall be free from kinks, open and unequally tensioned strands and other irregularities.

3.6 Lubrication

During manufacture of the rope, a suitable anti-friction compound, which shall retain its properties between –55 °C and +70 °C and which shall also have anti-corrosive properties, shall be applied to the wires and strands. Care shall be taken that for the purpose of application, the anti-friction compound is not heated above the upper temperature limit. A1 (Recommended lubricant is that specified in Def Stan 91-51. Additional guidance is given in Def Stan 01-5.) A1

3.7 Inspection

3.7.1 General. Throughout the tests given below the temperature and humidity should be normal and constant. Before every inspection operation, the inspector shall be satisfied that the measuring instruments are correctly calibrated.

3.7.2 Visual examination. All ropes should be examined visually in order to check the quality of manufacture and finish. The distance between any two broken wires, other than wires joined in accordance with **3.5.6**, shall be at least 300 m.

3.7.3 Measurement of diameter. This shall be carried out as given in **3.2.2.**

3.8 Testing

3.8.1 General. A complete report of all tests shall be supplied with the despatch documents.

3.8.2 Cutting test. The increase in the diameter of the wire rope after cutting shall not exceed the value indicated in Table 1. The measurement shall be made as near as possible to the end of the rope on both pieces. (This test may be carried out at the time of sampling for the various mechanical tests.)

3.8.3 Breaking strength of rope

3.8.3.1 *Test length.* The test length (distance between grips) shall be equal to at least 30 times the rope diameter and shall be not less than 300 mm for ropes having a diameter of 6 mm or less, and not less than 600 mm for ropes having a diameter of more than 6 mm.

3.8.3.2 *Test piece.* The minimum length of test piece is made up of the test length plus an allowance for gripping. The test piece shall be representative of the rope as a whole and free from defects. Prior to selection the end of the test piece shall be secured to prevent turn being put into or taken out of the test piece. In the same way the rope from which the test piece is taken shall be secured. When cutting the test piece from the rope neither the rope nor the test piece shall be damaged. When testing a rope to destruction it is useful to provide it with conical sockets. Care has to be taken to ensure that the casting material penetrates well into untwisted wires.

3.8.3.3 *Testing.* The load shall be applied progressively, the last 20 % being applied slowly, at a rate of approximately 10 N/mm^2 per second. The breaking load is reached when no further increase in load is possible.

3.8.3.4 *Evaluation of test.* Tests in which breakage occurs in or adjacent to the grips may be discarded at the option of the manufacturer in cases where the minimum breaking load is not reached.

3.8.4 Elongation test

3.8.4.1 *Definition.* For the purposes of this specification, elongation of a rope is as defined in 1.2(10).

3.8.4.2 *Preliminary procedure.* From each production length of wire rope a sufficient length shall be selected to provide an unobstructed test length of 250 mm minimum between the jaws of the test machine. This selected length shall be pre-stretched to remove constructional stretch and to bring the test length approximately into the elastic condition by the application of a load equal to 63 % of the minimum breaking load. This load shall be maintained for a minimum period of 2 minutes and then released to not more than 5 % of the minimum breaking load.

3.8.4.3 *Test procedure.* On the test length thus prepared and immediately following the preliminary procedure, the minimum gauge length of 250 mm shall be accurately measured, marked and recorded under an initial load equal to 5 % of the minimum breaking load of the rope. The load shall then be progressively increased until a load equal to 60 % of the minimum breaking load is reached, and it shall be maintained for a minimum period of 1 minute. The length between the gauge points shall again be measured. The difference between the two measurements is the elongation and shall be expressed as a percentage of the original gauge length. This percentage shall be in accordance with that listed in Table 2.

3.8.5 Proof test. Using the same test length as for the preceding elongation test the load shall be progressively increased until a value of 80 % of the minimum breaking load is reached and maintained for a minimum period of 5 seconds. The load shall then be released and the test length completely separated into its constituent wires and each wire shall be examined. Any broken wires shall be cause for rejection of the production length represented by the test length.

3.8.6 Preforming test. The end of the preformed wire rope shall be cut or sheared mechanically and two diametrically opposite strands unlaid for a distance of ten rope diameters or 50 mm, whichever is the greater. These strands shall then be relaid into position and the diameter of the rope measured at a distance of six rope diameters or 25 mm, whichever is the greater, from the end. The measurement thus obtained shall not exceed the values laid down in Table 1, Column 3.

NOTE. This test may be performed on the rope or on samples taken from the rope.

3.8.7 Re-tests. Should a test piece fail to fulfil the requirements of **3.8.3, 3.8.4** and **3.8.6** two further samples cut from the same end of the same length of rope may be subjected to the test that the first test piece failed, should the rope manufacturer so desire. If both these samples fulfil the requirements of the test the length shall be accepted or, if either fail, the rope length shall be deemed not to comply with the requirements of this standard.

3.8.8 Lubrication test. A white cloth held to the rope by light finger pressure shall be passed once over an approximate length of 300 mm of the rope. There shall be a noticeable amount of lubricant adhering to the cloth.

〈A1〉 **3.8.9 Endurance test.** An endurance test shall be carried out on each lot of wire rope in accordance with BS ISO 2020-2:1997, **5.10**. 〈A1〉

3.9 Reels

3.9.1 Reels used for winding the rope, either for handling, storage or despatch, shall be constructed from materials which are unlikely to corrode or damage the rope. Oak, sweet chestnut, French maritime pine or western red cedar shall not be used. The face of the reel barrel and the inside of the reel flanges shall be lined with inert water proof material before the rope is wound on to the reel.

3.9.2 The diameter of the barrel shall be not less than 40 times the nominal diameter of the rope.

3.9.3 More than one piece may be wound on a reel if all the pieces on the same reel are of identical diameter and construction and of the same batch. The lengths of the pieces so wound need not be equal.

3.9.4 The ends of the ropes shall be whipped or wrapped. The innermost end of each piece shall be passed through the side of the reel and left exposed.

3.9.5 Precautions shall be taken to protect the rope wound on the reel from the ingress of grit and moisture and from damage in transit. The exposed surface of the rope shall be covered with a layer of inert waterproof material held down by appropriate means.

3.10 Marking

3.10.1 Each piece of wire rope shall be identified by a metal tally or seal which bears the following information:

(1) The number of this British Standard , i.e. BS W 13.

(2) The nominal diameter and type of construction.

(3) The length of the piece.

(4) The manufacturer's name or identification mark.

(5) The order number(s).

(6) The test report number(s).

(7) The stamp of the inspector.

3.10.2 Each piece shall have the tally attached to the innermost end left free as described in **3.9.4.**

Table 1. Principal properties of wire ropes

1		2	3	4	5	6	7
Nominal diameter of wire rope		**Construction**	**Measured diameter of wire rope**		**Minimum breaking load**	**Increase in diameter after cutting**	**Approximate mass per 100 m**
			Max.	**Min.**		**Max.**	
mm	in		mm	mm	kN	mm	kg
1.6	1/16	7 x 7	1.8	1.6	2.15	0.23	1.2
2.4	A1 3/32 A1	7 x 7*	2.7	2.4	4.10	0.25	2.4
3.2	1/8	7 x 19	3.5	3.2	7.85	0.28	4.6
4.0	5/32	7 x 19	4.4	4.0	10.70	0.43	6.7
4.8	3/16	7 x 19	5.2	4.8	16.50	0.48	9.7
5.6	7/32	7 x 19	6.0	5.6	22.25	0.51	12.8
6.4	1/4	7 x 19	6.8	6.4	28.40	0.53	16.4

* A 7 X 19 construction is permitted for this diameter rope, as long as it conforms with the properties specified.

Table 2. Elongation test

1		2	3	4	5	6
Nominal diameter of wire rope		Minimum breaking load	Pre-stretching load (63 % of minimum breaking load)	Load of first reading (5 % of minimum breaking load)	Load of second reading (60 % of minimum breaking load)	Maximum percentage elongation $\frac{\text{elongation}}{\text{gauge length}} \times 100$
mm	in	kN	kN	kN	kN	
2.4	3/32	A1 4.10 A1	2.60	0.21	2.45	0.80
3.2	1/8	A1 7.85 A1	4.95	0.39	4.70	0.95
4	5/32	A1 10.70 A1	6.70	0.54	6.40	1.00
4.8	3/16	A1 16.50 A1	10.40	0.82	9.80	1.00
5.6	7/32	A1 22.25 A1	14.00	1.12	13.35	1.00
6.4	1/4	A1 28.40 A1	17.90	1.42	17.10	1.00

Appendix A

Handling of ropes

A.1 The ropes in this specification need careful handling to ensure that the lays as manufactured are not disturbed, and further that the rope is not allowed to form a loop in itself which, if pulled tight, will produce a kink. In this class of rope the kink is shown by the centre strand or core leaving the rope's centre and either lying between the outer strands, or even protruding from the rope in the form of a small loop.

A.2 When unwinding a rope the reel should be mounted in a stand with an axle shaft through the centre hole of the reel, to enable the rope to be pulled off in a straight line. It is not advisable to pay off rope from a reel to make flat coils on the floor and then pull out the end for cutting to lengths. This latter practice is very conducive to core protrusion.

A.3 When the lengths have been cut off it is frequently necessary, owing to the length involved, to coil up the cut lengths by hand. In such cases the hand coil should be of large diameter, say not less than 50 diameters of the rope involved, with a minimum of 150 mm diameter. When these hand made coils are run out, it should be done by the 'wheeling' method, or by rotating the coil so that the rope is paid out in a straight line. If, when handling a length of rope, the rope forms a loop on itself this indicates a localization of turn. This must be eliminated by taking the turn out and never by pulling tight; the latter will produce permanent malformation of core protrusion.

A.4 The ropes, having been treated with a lubricant, will tend to retain dust and grit with which they may come in contact. During handling, therefore, precautions should be taken to minimize such contamination.

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