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TECHNICAL REPORT

TR-AE-14

EXAMINATION OF A FOREIGN-AIRCRAFT RUBBER TIRE CASING

30 JANUARY 1953

AIR TECHNICAL INTELLIGENCE CENTER
WRIGHT-PATTERSON AIR FORCE BASE
DAYTON, OHIO

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Project Monitor
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TECHNICAL REPORT NO. TR-AE-14

EXAMINATION OF RUBBER TIRE CASING FROM MIG-15 AIRCRAFT NO. 120147

30 JANUARY 1953

Prepared By

BATTELLE MEMORIAL INSTITUTE
COLUMBUS, OHIO

for

AIR TECHNICAL INTELLIGENCE CENTER
WRIGHT-PATTERSON AIR FORCE BASE
OHIO

T52-18486

SECRET
SECURITY INFORMATION

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SUMMARY

Purpose

To examine, analyze, and evaluate a section of a Soviet rubber tire casing from MIG-15 aircraft No. 120147.

Factual Data

A section of a tire casing from MIG-15 aircraft No. 120147 was received for technical analysis and evaluation. The tire-casing sample was photographed, and scale drawings of cross-sectional and lateral views were made to show construction details. The tire-casing section was then examined for markings, and all markings were recorded. This report also includes markings which were transcribed from a complete duplicate tire casing of a Soviet MIG-15 aircraft; these markings were obtained from ATIC for interpretation and inclusion in this report. The tire-casing sample was sectioned and reconstructed to determine the method of fabrication. The sectioned parts were then submitted to various standard chemical, physical, and mechanical tests. Load-deflection curves for a MIG-15 tire casing were received from ATIC and are included in this report. All of the data are presented in Section I.

This report was prepared at Battelle Memorial Institute by D. McNulty and S. Palinchak.

Discussion

The tire-casing sample as received appeared to be in good condition, except for a small area which was scorched, probably by fire. The tire-casing tread showed slight, uniform wear.

The markings on the tire-casing section showed the size to be 660 x 160 mm, or 26 x 6.3 inches. This size is similar to the 26 x 6.6-inch size of the tire casings used on U. S. F-86 Sabrejet aircraft. The Russian letter "B" which followed the casing-size numerals is probably an abbreviation for the Russian word "ВОЗДУШНЫЙ", meaning "aircraft" or "aerial". Soviet markings on the outside surface indicated that the casing had been fabricated in 1950.

Breakdown and reconstruction of this tire-casing section revealed some unusual design features. The thickness of the rubber between the carcass and the bottom of the tread pattern (underskid thickness) was found to be 250 per cent of the tread depth, if it is assumed that tread wear was negligible, as compared to a minimum of 30 per cent underskid thickness required for equivalent-size U. S.-aircraft casings. An F-86E tire casing of one U. S. manufacturer has an underskid thickness of 60 per cent. The increased underskid thickness in the Soviet casing might have been employed for the purpose of increasing the ply rating. However, it is entirely possible that friction-heat buildup in the thicker underskid section would not allow the Soviet tire casing to withstand the dynamic tests given to 26 x 6.6-inch U. S.-aircraft casings. The actual ply rating for this casing sample can be determined only by performance tests on a complete similar Soviet tire casing.

No breaker strips had been used in the Soviet tire casing. Some modern U. S.-aircraft casings are constructed without breaker strips. However, in spite of the added weight of breaker strips, most U. S. tire manufacturers design them into the tire casings to provide extra reinforcement against bruises and breaks resulting from the impact shock of landing on hard, rough terrain. Examination showed that the cushion material was embedded between the three plies of cord next to the tread. Some tire casings have been built in this fashion by certain U. S. manufacturers.

Chafing strips had been provided in the Soviet casing to protect the cord plies from possible damage by chafing action caused by contact with bead seats and rim flanges, or damage during mounting of the casing. USAF specifications(1) require at least one chafing strip per bead. The Soviet casing had only one chafing strip for the two beads (Section I, Figure 1). However, the Soviet chafing strip fulfills the requirements for covering as specified for USAF aircraft-tire-casing chafing strips, namely, that at least 75 per cent of the base of the bead and any exposed ply edges are to be covered.

Two wire beads, an inside and an outside bead, had been employed in the construction of each flange (rim) of the tire casing (Section I, Figure 1). Each bead contained nonplated wires of two gages, 0.018- and 0.038-inch diameter, made of good-quality, cold-rolled, medium-carbon steel. In the U. S., wires for this application are often copper plated to prevent corrosion. In domestic practice, only the heavier wire is used. The 253,000-psi tensile strength of the heavier Soviet wire compares favorably with the strength of bead wire used in the U. S. Apparently, the Soviets have used the finer wire to hold the heavier wire in place during fabrication, since only one 0.018-inch wire was used to about every eight of the 0.038-inch wires. The wires in U. S. beads are usually more uniformly spaced than were those in the Soviet bead. The use of the fine wire and the random placement of the heavier wires may

(1) MIL-C-5041, "Aircraft Pneumatic Tire Casings", Amendment 2, Paragraph 3.10., February 8, 1951.

indicate that the Soviets were experiencing some difficulty in bead construction when this particular tire casing was fabricated. This type of bead construction is known as "Pierce type" (generally refers to a flat strand of parallel wires; in this case, refers to eight wires held in place by an interwoven filler wire), and was abandoned by Goodyear several years ago because of the high cost of processing with no increase in performance(1).

Inspection showed that eight plies of a cord fabric had been used. The polarizing microscope showed that the cord was made of nylon or nylon-type filaments. The cord gage was somewhat larger than that normally employed in U. S. practice in fabrics for tire-casing plies; 0.032-inch-diameter cord had been used by the Soviets, whereas 0.019- to 0.021-inch cord is acceptable in the U. S. However, the ZZS-twist construction with 25.4 turns per inch was similar to that used in the U. S.

Tests were conducted at the Physics Branch of the Materials Laboratory, WADC, to determine whether a sample of the cord from this Soviet casing was nylon or perlon(2). The infrared analysis and melting-point data indicated that the cord sample from the MIG-15 tire casing was similar to samples of perlon from the West Zone of Germany that had previously been tested at the Materials Laboratory, WADC. It was the opinion of that laboratory that the MIG-15 tire cord was perlon. It is of interest to note that a documental report(3) indicated the shipment of a large portion of East Germany's production of perlon to the U.S.S.R. for jet-aircraft tires.

(1) Memorandum Report, Airplane Tire Design Section (102D8) - Development Department, The Goodyear Tire and Rubber Company.
(2) This information was included with correspondence from the Technical Analysis Division, ATIC; Enclosure No. 1, an extract from the report WCRTT-T52-263 of the Materials Laboratory, WADC.
(3) 30-86905, "Manufacture of Perlon", CIA, 1951, F-3 (SECRET).

No balance patches or balance dough were present in the section examined. The workmanship appeared to be good, and indications were that all parts had been machine cut and fabricated.

The tread design was a nonskid type having seven ribs separated by grooves, which were interspersed with "spacer bars" alternately positioned between the ribs of the tread. No groove cracks were found in the casing section studied. This design may have been employed for a purpose similar to that of a new slotted-tread design used experimentally by a domestic aircraft-tire manufacturer (Thompson Aircraft Tire Corporation). This U. S. tread design consists of a series of staggered slots, spaced to carry heavy loads and provide proper displacement of tread rubber when the tire deflects on ground contact. The manufacturer claims that the new slotted design eliminates groove cracking and gives longer casing life.

Chemical and infrared analyses of the rubber used in the Soviet-aircraft tire casing showed that:

1. The tread and sidewall stocks were similar in composition, i.e., were mixtures of GR-S and natural rubber. Approximately 55 to 65 per cent GR-S-type rubber was present, based on the assumption that a 75/25 butadiene/styrene GR-S stock was used.
2. The cushion and the bead filler were made of natural rubber.
3. The bead insulation was made of polybutadiene.
4. The inner-ply and outer-ply skim coatings were made of natural rubber.

WADC supplied load-deflection curves for the MIG-15 tire casing mounted on a standard U. S. 26 x 6.6-inch Type VII wheel. At the time of testing, the appearance of the tread wear indicated that the tire probably had been operated at approximately 2 inches of deflection; no estimation of inflation pressure was made, since slight changes in operating deflection considerably alter the inflation for a given load. However, it was reported later that about 80 psi of air pressure remained in the tire when it was removed from the MIG-15. Since it is probable that 10 to 20 psi of air pressure was lost between the time the aircraft was "downed" and its recovery, it is estimated that approximately 100-psi air pressure was maintained in the tire casing by the Soviets.

Analysis of the various component parts of the tire indicated that the Soviets have used a high percentage of synthetic rubber in the manufacture of this tire casing for use on jet aircraft such as the MIG-15 where maximum performance is required. They have used a tread design in which no groove cracking was evident, and have increased the underskid depth by about 200 per cent over that required in U. S. tires. The breaker strips have been eliminated, and only one chafing strip has been used for both beads instead of one per bead. By increasing the underskid depth, the Soviets have probably increased the ply rating (index of maximum recommended load for a specific type of service; not necessarily the number of cord plies) of the casing. However, this increased underskid thickness could lead to high dynamic heat buildup which would affect the maximum number of landings that could be made with such a tire. On the other hand, if it can be assumed that there would be no excess dynamic heat buildup because of the increased underskid depth, and if the casing is judged on the basis of adhesion, it is estimated that the Soviet casing should withstand, without failure, about 30 landings with a tire pressure of 100 psi and a landing speed of about 120 to 130 miles per hour.

It is felt that ply separation would take place more readily in the Soviet casing than in U. S. tires, but this can be determined only by actual service testing of a similar Soviet casing.

It is interesting to note that markings on the Soviet casing indicated that it probably had been fabricated in 1950. About May, 1951, a U. S. tire manufacturer was fabricating aircraft test tires containing synthetic rubber[1]. This is an example of the advances made by Soviet technologists in the use of synthetic rubber for aircraft tire casings.

One of the most critical aspects of tire-casing performance is that involving adhesion of the various components. The tread and cushion adhesions of the Soviet casing were good, but the outer-ply adhesion was somewhat low. It is expected that ply separation may be one of the weaknesses of the Soviet tire because of the low adhesion between plies. Data obtained from tests on representative "dumb-bell" specimens taken from the tread and sidewalls of the Soviet casing indicated that the tensile strength was below U. S. standards for GR-S passenger-car tread stocks; no data were obtainable for similar U. S.-aircraft tire casings. Qualitative determinations indicated that the low-temperature properties of the Soviet tread and sidewall probably would not meet USAF specifications. Abrasion test results for the tread and sidewall of the Soviet casing compared favorably with abrasion values obtained on the tread of a tire casing for a U. S. F-86 aircraft.

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(1) Information obtained from Research and Development Project Information Report, "New Types of Wheels, Brakes, and Tires for Aircraft", T.D.O. R-452-138, May 31, 1951.

Conclusions

The conclusions presented are based on observations and test results obtained on a casing section from only one tire of MIG-15 aircraft No. 120147. This casing section showed a slight amount of uniform wear and had a scorched area, probably caused by fire. It is possible, therefore, that the test results would have been somewhat different if an unused tire casing had been tested. Also, it is possible that this section is not representative of other MIG-15 tire casings which are currently undergoing tests, or of tire casings from tires on other MIG-15 aircraft. With these reservations, the following conclusions were drawn:

1. This section of tire casing contained a large amount of synthetic rubber. This indicates that the Soviets may have aircraft tire casings containing a large quantity of synthetic rubber in service on MIG-15 aircraft. U. S. tire casings (for similar aircraft) containing synthetic rubber have been used only on an experimental basis.

2. The tread and sidewall of the Soviet casing were similar in composition; both contained GR-S (butadiene-styrene copolymer) synthetic rubber and natural rubber. Approximately 55 to 65 per cent GR-S rubber was present.

3. It is not possible to estimate accurately the number of normal landings possible for the Soviet tire casing before replacement would be needed. However, it is postulated that, under ideal conditions, the Soviet tire should withstand approximately 30 landings at 100-psi inflation pressure and landing speeds of about 120 to 130 miles per hour. This conclusion is based on the following:

a. The MIG-15 aircraft weighs about 3,000 to 4,000 pounds less than the F-86E aircraft.

b. The Soviet-tire tread and sidewall had approximately the same abrasion resistance, in laboratory tests, as the tread on a U. S. tire casing used on jet aircraft.

c. The underskid thickness of the Soviet tire casing was about 200 per cent greater than that required by specifications for U. S.-aircraft tire casings. Laboratory examination revealed a 60 per cent underskid thickness on an unused tire casing of an F-86E aircraft. A minimum of 30 per cent underskid thickness is required by U. S. specifications for aircraft tire casings.

d. No groove cracks were found in the tread of the Soviet tire-casing section examined. The tread design (a nonskid type) may be responsible, to a large extent, for this good condition of the GR-S stock tread.

e. Adhesion between the (1) tread and adjacent fabric layer, and (2) cushion and adjacent fabric layer was good. Inner-ply adhesions may be considered fairly good. However, the adhesion between the outer-ply skim coating and the adjacent fabric ply was somewhat low.

4. It is not likely that this Soviet tire with its large quantity of GR-S synthetic rubber would withstand as many landings at temperatures below -40 F as would a similar natural-rubber tire. The Soviet tread and sidewall were very stiff at -40 F. U. S.-aircraft casings are required to withstand severe bending tests at this temperature.

5. This tire-casing section is the first casing of Soviet construction examined in which nylon-type cord was used. Indications are that the material was perlon. The cords were of a larger gage than is used in the U. S., but the strength and method of construction were similar to those of U. S. cords.

6. Breakdown and reconstruction of the Soviet casing section showed it to be of good construction with the following design features which are different from general U. S. practice:

a. The thickness of the rubber between the bottom of the tread pattern and the carcass was about 10 times that required by U. S. specifications.

b. No breaker strips were used in the tread area of the tire casing.

c. The cushion rubber was embedded between the cord plies in the tread area.

d. Only one chafing strip was used for the two metal beads (outside and inside) in the Soviet casing, as compared to one chafing strip for each bead in domestic practice.

e. Two different sizes of wire were employed in each bead of the Soviet casing. The strength of the larger gage wire compared favorably with that used in U. S. tire casings.

7. The mechanical properties of the Soviet-casing tread and sidewall stocks showed much lower tensile strength and somewhat lower ultimate elongation than are found in a U. S. GR-S tread stock used for automobile tires. (Data on GR-S tread stock for U. S.-aircraft tire casings were not obtainable at the time of this report.)

8. Very fine particle-size carbon black was used as the primary filler in the Soviet tread and sidewall stocks.

SECTION I

1. General Description and Construction Details

A section of a black rubber tire casing from Soviet MIG-15 aircraft No. 120147 was received for analysis. This casing section was designated as BMI No. 302-64 and photographed (Figure 1). Figures 2 and 3 are scale drawings of a cross section and a lateral section, respectively, of the casing. Call outs on the drawings illustrate critical design elements of the casing. The tire casing was in good condition except for a small area which appeared to have been damaged by fire. The casing section studied showed slight, uniform tread wear.

The casing included eight plies of cord: two tread plies, which extend around the casing but do not "double back" around the beads, and six carcass plies, which extend around the casing periphery. Two of these carcass plies "doubled back" around the outer bead and the other four "doubled back" around the inner bead. The cord fabric was plied as opposing, bias-cut, rubber skim-coated sheets of weftless cords. Each cord was two plies (strands) of ZZS twist.

The tread of the Soviet casing was clean and uniform with no evidence of groove cracking. It measured 0.35 inch in thickness at the crown of the casing, with a molded skid-tread depth of 0.1 inch. Thus, the underskid thickness measured 0.25 inch. The tread design was a nonskid type having seven ribs, each 0.5 inch wide and separated by grooves 0.2 inch wide and 0.1 inch (average) deep. These grooves were interspersed with "spacer bars", 0.1 inch wide, at intervals of 3.6 to 3.8 inches. The "spacer bars" were alternately

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Figure 1. Section of MIG-15 Tire Casing As Received

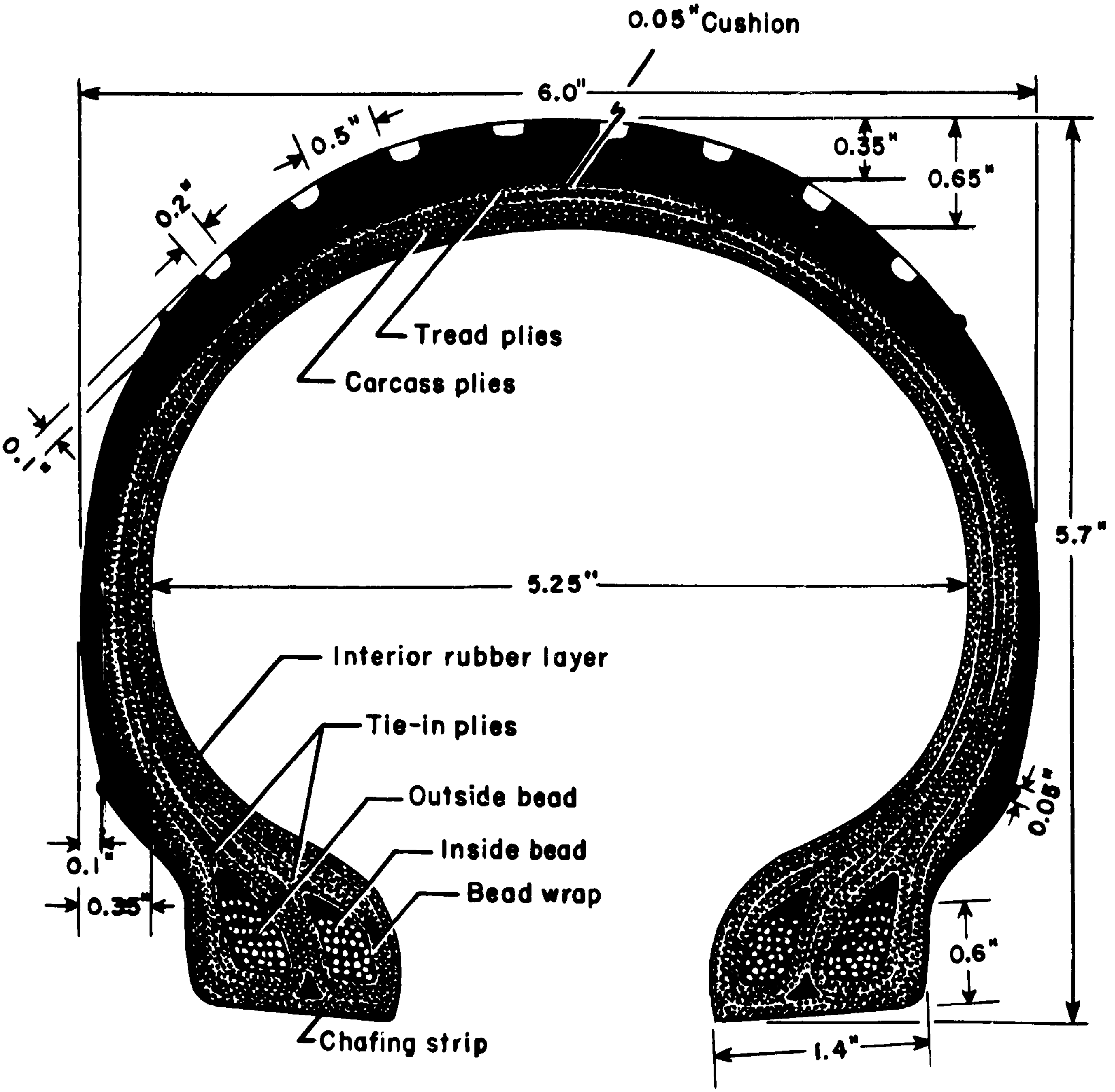


FIGURE 2. CROSS SECTION OF MIG-15 AIRCRAFT TIRE CASING.

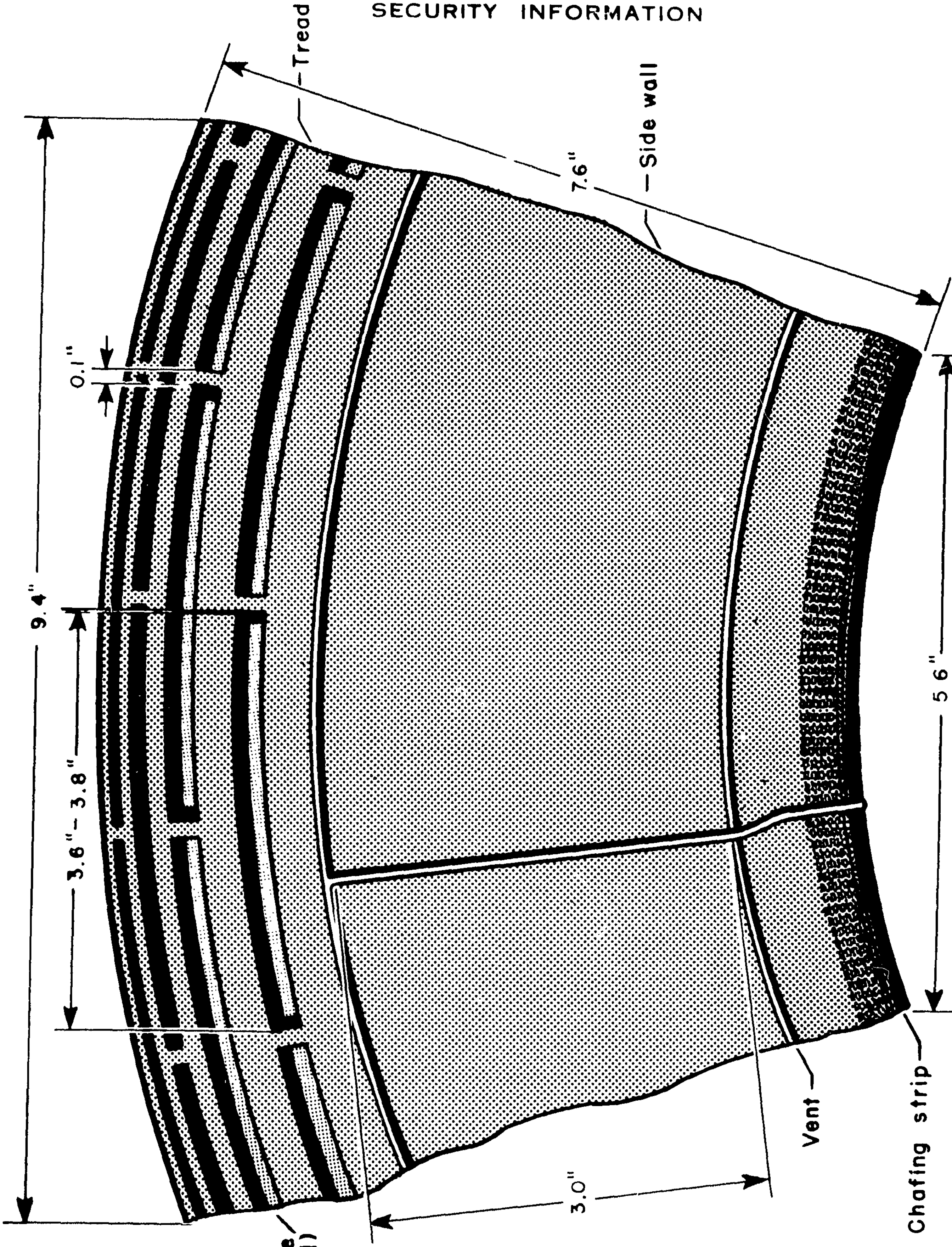


FIGURE 3. LATERAL SECTION OF MIG-15 AIRCRAFT TIRE CASING.

positioned between the ribs of the tread, and may possibly have been used as air vents when the casing was being molded.

The tread design of this Soviet-aircraft tire casing may have been employed to function similarly to a new slotted tread design used by a domestic aircraft-tire manufacturer, although the Soviet design is not identical with the domestic design. The tread design of the domestic casing consists of a series of staggered slots, spaced to carry heavy loads and to provide proper displacement of the tread rubber when the tire deflects at the point of ground contact. The U. S. manufacturer claims that the new slotted design eliminates groove cracking, which is prevalent in several brands of straight-rib tires. This new (1951) slotted tread design is claimed to give "extra landings" or longer casing life. Evaluation tests have been made by several airlines using DC-3, DC-4, and DC-6 aircraft(1).

The cushion rubber was applied as a skim coating between each of the three plies which were next to the tread. The cushion rubber appeared only at the crown of the tire and measured approximately 0.03 inch thick. The thickness of the skim coating below the cushion, in the sidewall area of the casing, measured 0.01 inch.

Each rim flange contained two beads, an outside bead and an inside bead. The outside bead contained 38 wires of 0.038-inch diameter and 5 wires of 0.013-inch diameter. The finer wires apparently had been used to hold the heavier wires in place during fabrication. Rubber insulation covered all of the wires and a bead filler had been used. The outside bead was wrapped with cotton fabric and was completely surrounded by a tie-in ply (flipper), both

(1) Aviation Week, p 59, October 15, 1951.

ends of which extended well above the bead. The inside bead contained 48 wires of 0.038-inch diameter and 6 wires of 0.018-inch diameter. The method of construction of the inside bead was the same as that of the outside bead.

Mold vents were prominent on the sidewalls of the casing, in the form of smooth, half-round cylindrical-shaped protrusions, and averaging 0.05 inch in diameter. Two parallel vent lines on both sidewalls extended longitudinally around the tire, three inches apart. One was located near the tread and the other was adjacent to the bead edge. Additional vent lines were located at right angles to the longitudinal vents, i.e., radially, at 6-inch intervals, on both sidewalls. These lines extended radially from the vent, located near and parallel to the tread, past the bead area and terminated at the interior of the casing. This system of venting is no longer widely used on domestic tire casings.

Molding register appeared to be excellent. A mold ring line lay almost exactly in the middle of the inside surface, i.e., 7-5/16 inches from each bead edge of the casing. This indicates excellent "register", i.e., care was used in mold handling and maintenance.

The surface condition was generally good. The tread area showed slight, uniform wear and was in good condition, except for one section approximately four inches in length and three inches in width, which allegedly had been damaged by fire. The sidewall areas were smooth and showed no cracking. The bead areas were smooth and not mutilated, indicating that care had been taken in manufacture and installation. The interior surface consisted of a thin, relatively smooth rubber skim coating which had no noticeable cracks or breaks.

2. Markings

A thin piece of pale red-colored rubber, 0.6 inch x 1.1 inches, was impressed into one sidewall and bore the following molded numerals: 041 (the numbers were 0.4 inch in height).

On the opposite sidewall, the following numerals were written in an indelible-type ink: 1981.

The markings listed on the following page were transcribed by ATIC personnel from a Soviet-aircraft tire casing identical with the tire casing designated as BMI No. 302-64, and were submitted for inclusion and interpretation in this report. This duplicate tire casing reportedly was from the same MIG-15 aircraft as the casing section (BMI No. 302-64) discussed in this report.

3. Composition and Physical and Mechanical Properties

The Soviet tire-casing sample from the MIG-15 aircraft was sectioned, and the various parts were subjected to chemical analysis and tests for physical and mechanical properties.

Tables I and II show the data obtained from composition analysis and physical and mechanical tests. Where possible, the test results are compared with data for typical U. S. tire-casing stocks. The military specification for U. S.-aircraft pneumatic tire casings[1] was used as a frame of reference for evaluation of the Soviet tire-casing section.

(1) MIL-C-5041, "Aircraft Pneumatic Tire Casings", Amendment 2, February 8, 1951.

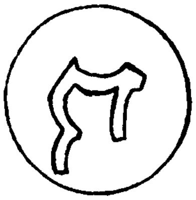
Markings	Interpretation
660 × 160 B	Dimensions in millimeters. "B" is probably an abbreviation for the Russian word "ВОЗДУШНЫЙ" meaning aircraft or aerial.
IV СЕРИЯ	Series IV.
8 СГ	Eight ply, indicating the number of tire-casing plies.
	Russian letter Я, identifying Yaroslavl Rubber Factory.
ЯV5 1009484	Serial number.
ДКТП	It is not known whether these letters were molded or stamped. If stamped, they probably indicate a stamp of Technical Industrial Control.
A-50 36	Probably the date of manufacture - 1950.
041	?

TABLE I. COMPOSITION AND PHYSICAL AND MECHANICAL PROPERTIES OF TIRE-CASING TREAD AND SIDEWALL

	Soviet-Aircraft Tire Casing		Remarks
	Tread	Sidewall	
Composition			
Copolymer	GR-S and natural	GR-S and natural	There are no values for U. S. counterparts available for comparison since U. S. specifications are based largely on natural-rubber tires. GR-S tread stocks containing approximately 30 per cent carbon black have tensile strengths of 2,700 to 3,500 psi and elongations of 400 to 600 per cent.
Rubber content, per cent	53.6	53.3	
Carbon black, per cent	34.9	29.4	
Ash, per cent	3.3	3.6	
Acetone extract, per cent	6.5	6.8	
Physical and Mechanical Properties			
Specific gravity, at 25 C	1.16	1.16	
Adhesion to adjacent fabric ply, lb/in.(1)	50	50	
Unaged:			
Durometer hardness, Rex	67	67	
Tensile strength, psi(2)	1,930	1,718	
Ultimate elongation, per cent	233	270	
Stress, psi, at elongation of:			
100 per cent	473	423	
200 per cent	1,210	1,190	
Low-temperature flexibility and Rex hardness at:			
-40 F	Very stiff(90)	Very stiff(90)	
-65 F	Not flexible(95)	Not flexible(95)	
Abrasion resistance, per cent(3)	93.3	103.2	

TABLE I. (CONTINUED)

	Soviet-Aircraft Tire Casing		Remarks
	Tread	Sidewall	
Aged 7 days at 212 F:			-
Durometer hardness, Rex	30	30	
Tensile strength, psi(2)	902	1,105	
Ultimate elongation, per cent	63	83	
Low-temperature flexibility and Rex hardness at:			
-40 F	Very stiff(90)	Very stiff(90)	
-65 F	Not flexible(95)	Not flexible(95)	
Abrasion resistance, per cent(3)	55.2	50.9	

(1) Adhesion data obtained using ASTM method designated D-413-39.
(2) Tensile strength determined by ASTM method designated D-394-47.
(3) Abrasion resistance determined using ASTM method with E. I. du Pont de Nemours and Company abrader.

TABLE II. COMPOSITION AND PHYSICAL AND MECHANICAL PROPERTIES OF TIRE-CASING CUSHION, INNER- AND OUTER-PLY SKIM COATINGS, BEAD FILLER, AND BEAD INSULATION

	Soviet-Aircraft Tire Casing				
	Cushion	Inner-Ply Skim Coating	Outer-Ply Skim Coating	Bead Filler	Bead Insulation
Composition					
Polymer	Natural	Natural	Natural	Natural	Polybutadiene
Rubber content, per cent	57.0	58.1	54.7	57.8	41.0
Carbon black, per cent	30.0	13.3	11.2	27.8	23.8
Ash, per cent	3.1	18.8	23.6	5.1	6.0
Acetone extract, per cent	8.0	7.4	8.6	7.5	27.9
Physical and Mechanical Properties					
Specific gravity, at 25 C	1.13	1.18	1.21	1.12	1.21
Adhesion to adjacent fabric ply, lb/in.(1)	50	25	15	-	-
Low-temperature flexibility at:					
-40 F	Flexible	-	-	-	-
-65 F	Flexible	-	-	-	-

(1) Adhesion data obtained using ASTM method designated D-413-39.

Table III presents the results of spectrographic analysis of ash samples from the various rubber parts of the casing section.

The load-deflection data given in Table IV, and graphically presented in Figures 4 and 5, were reproduced from a table and graphs, respectively, obtained from WADC for inclusion in this report. Table IV provides data for use in comparing load-deflection curves for a tire from the MIG-15 and an F-86E tire. The load-deflection curves, Figures 4 and 5, compare the MIG-15 tire, mounted on a standard U. S. 26 x 6.6-inch Type VII wheel, with (1) a USAF rayon-cord-ply, 26 x 6-inch tire, and (2) a USAF nylon-cord-ply, 26 x 6-inch tire, respectively.

Observation of the tread wear indicated that the tire probably had been operated under approximately 2 inches of deflection. The inflation pressure was not estimated, since slight changes in operating deflection considerably change the degree of inflation for a given load. However, the following load ratings are given for materials having approximately the same physical properties as rayon and nylon; they were reproduced from a WADC memorandum regarding the load-deflection curves:

Material	Maximum Static-Load Rating, lb	Inflation, psi
Rayon	4,700	80 to 90
Nylon	5,900	100 to 120

In comparing the MIG-15 nylon-type-cord-ply tire with a 26 x 6-inch USAF rayon-cord-ply tire (Figure 4) at inflation pressures of 60, 80, and 100 psi, the MIG-15 tire was somewhat softer, i.e., it showed a higher deflection

TABLE III. SPECTROGRAPHIC ANALYSIS OF ASH SAMPLES FROM VARIOUS RUBBER COMPONENTS OF MIG-15 TIRE-CASING SECTION

Ingredients(1)(2)	Rubber Components						
	Tread	Sidewall	Cushion	Inner-Ply Skim Coating	Outer-Ply Skim Coating	Bead Filler	Bead Insulation
Zn	60–80	60–80	75–95	75–95	75–95	65–85	0.5–5.0
Ca	1–10	1–10	0.5–5.0	0.1–1.0	0.4–4.0	0.3–3.0	1–10
Fe	0.5–5.0	0.5–5.0	0.3–3.0	0.01–0.1	0.3–3.0	0.03–0.3	0.1–1.0
Si	10–30	10–30	1–10	0.1–1.0	5–15	1–10	20–40
Al	0.5–5.0	0.5–5.0	0.4–4.0	0.02–0.2	0.6–6.0	0.1–1.0	0.5–5.0
Mg	1–10	1–10	0.3–3.0	0.1–1.0	0.5–5.0	0.5–5.0	50–70
Cu	0.01–0.1	0.01–0.1	0.02–0.2	0.005–0.05	0.005–0.05	0.05–0.5	0.02–0.2
P	0.05–0.5	-	0.2–2.0	-	-	-	-
Ni	0.02–0.2	0.02–0.2	0.005–0.05	-	0.01–0.1	0.01–0.1	0.01–0.1
B	<0.001	<0.001	<0.001	-	<0.001	<0.01	<0.01
Ti	0.01–0.1	0.01–0.1	0.01–0.1	-	0.01–0.1	0.01–0.1	0.01–0.1
Mo	-	-	-	-	-	0.02–0.2	-
Sn	-	-	-	-	-	0.005–0.05	0.001–0.01
Mn	0.01–0.1	0.01–0.1	0.005–0.05	-	0.005–0.05	0.001–0.01	0.005–0.05
Cr	0.01–0.1	0.01–0.1	0.005–0.05	-	0.005–0.05	-	-
Pb	0.05–0.5	0.05–0.5	0.05–0.5	0.05–0.5	0.05–0.5	0.02–0.2	0.02–0.2
Ba	0.05–0.5	0.05–0.5	0.01–0.1	<0.01	0.01–0.1	0.05–0.5	0.05–0.5
Na	-	-	-	-	-	0.5–5.0	-

(1) Ingredients are determined as oxides by spectrographic analysis, but are not necessarily added to or present, as such, in the rubber.
(2) Throughout this table, the ingredient percentage ranges are reported on the basis of the ash.

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TABLE IV. DATA FOR USE IN COMPARISON OF LOAD-DEFLECTION CURVES FOR TIRE CASINGS FROM MIG-15 AND F-86E AIRCRAFT(1)

Characteristics	MIG-15	F-86E
Weight of aircraft, loaded, lb	10,435	14,400
Weight of aircraft, light, lb	8,810	11,660
Landing speed, mph	115 mph T.D.	126 mph T.D.
Tire size		
Main wheels	600 mm x 160 mm (26 x 6.3 in.)	26 x 6.6 in.
Nose wheel	18-in. OD(2)	-
Tire pressure, psi		
Main wheels	-	135-150
Nose wheel	-	48-53
Operating deflection, in.	2 (estimated)	-
Number of landings (main wheels)	(3)	-
Ideal conditions	-	10-15
Black top	-	5
Landing mats	-	2

(1) See Figures 4 and 5. The data shown were reproduced from a WADC memorandum.
(2) As measured on photograph.
(3) Estimated number of landings with 100-psi inflation = 30.

Note: 1. 85 per cent of static weight is usually supported by the main wheels.
2. The inflation of the MIG-15 tire casing as received at the Cornell Aeronautical Laboratories was 30 to 35 psi.

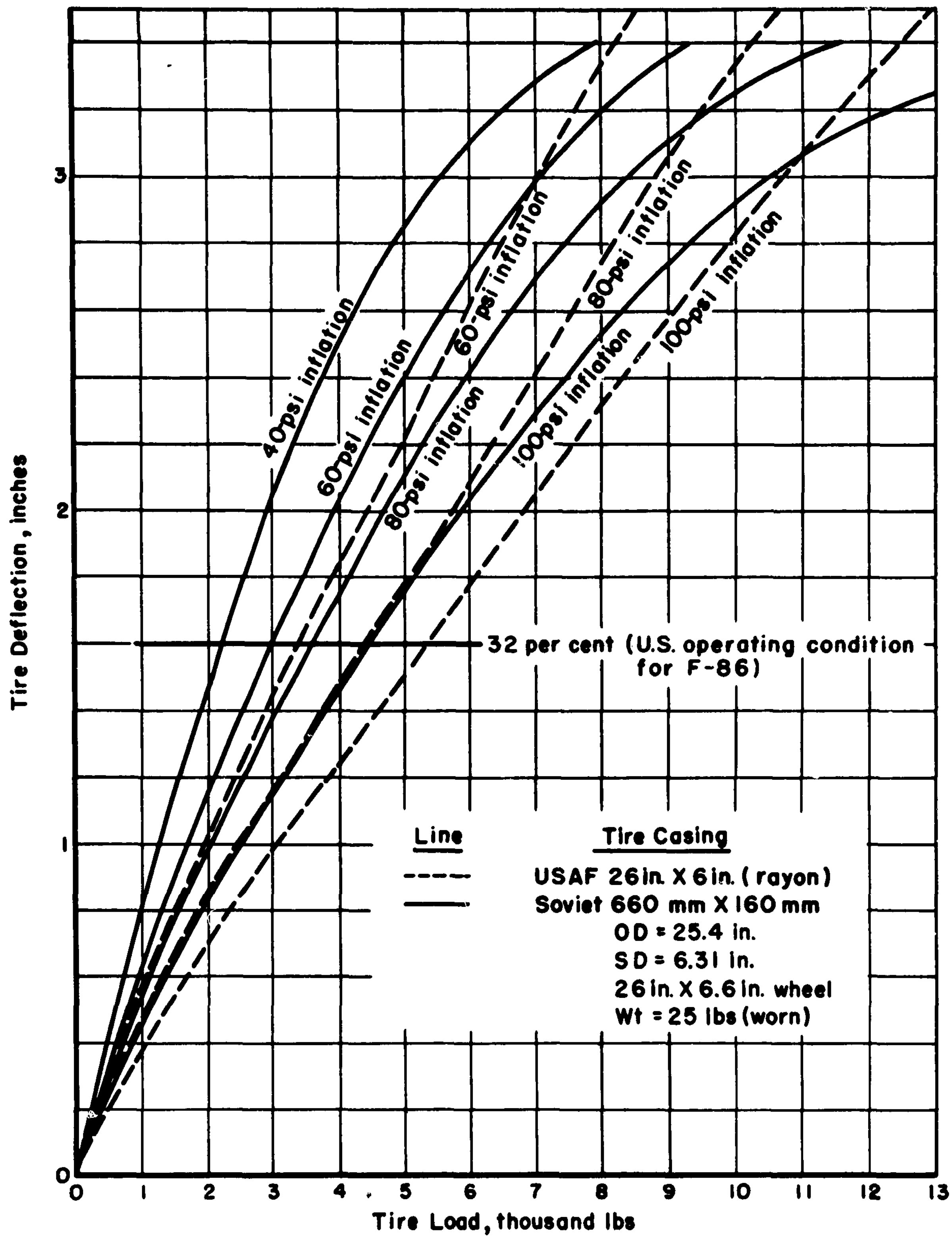

FIGURE 4. LOAD-DEFLECTION CURVES, COMPARING THE MIG-15 TIRE CASING WITH A U.S. TIRE CASING OF SIMILAR SIZE (WITH RAYON-CORD PLIES)

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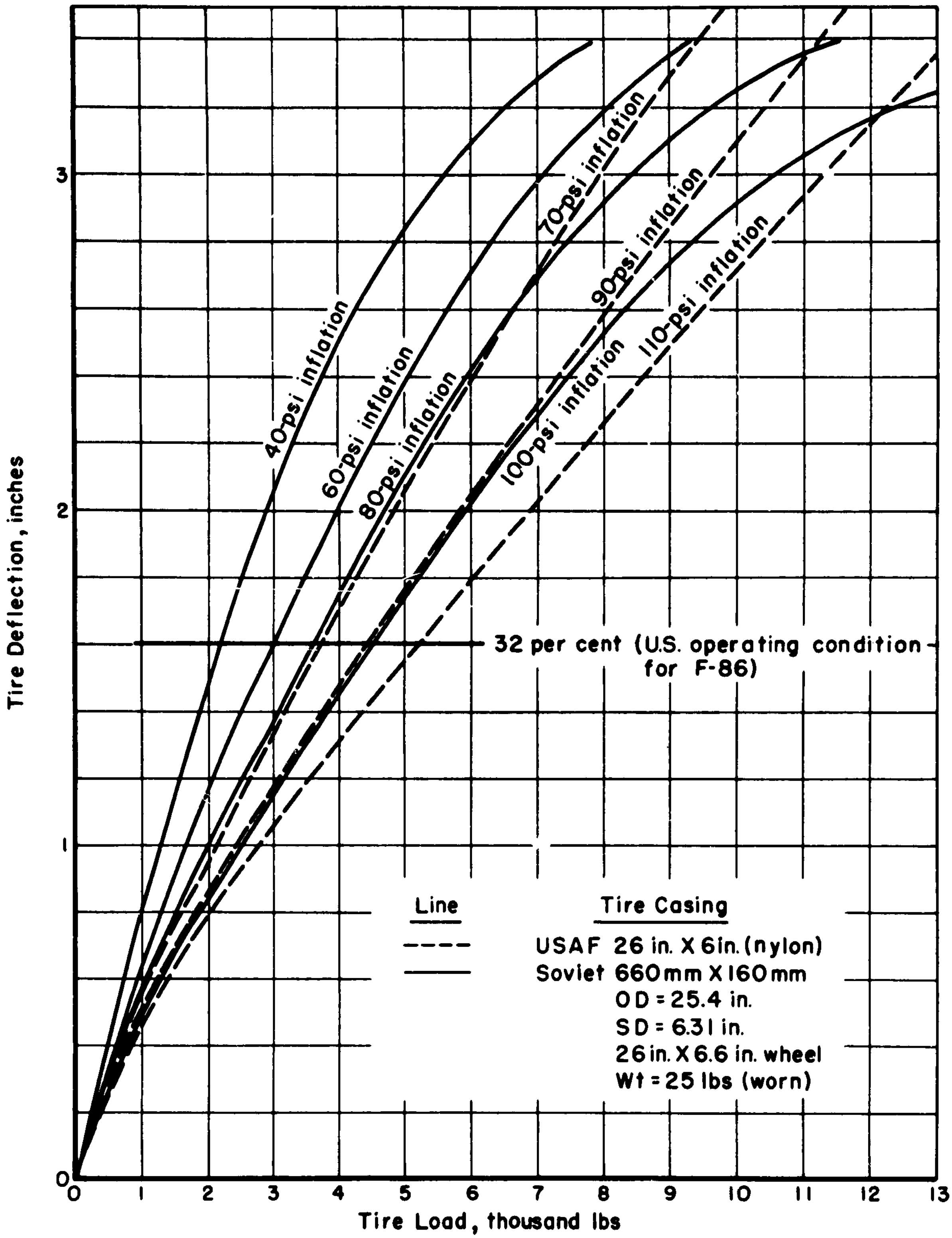

FIGURE 5. LOAD-DEFLECTION CURVES, COMPARING THE MIG-15 TIRE CASING WITH A U.S. TIRE CASING OF SIMILAR SIZE (WITH NYLON-CORD PLIES)

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value than the U. S. tire at a given load up to about a 3- to 3.18-inch deflection, where an inversion took place and the MIG-15 tire showed a lower deflection value at a given load than did the U. S. tire.

Figure 5 shows a similar comparison between the MIG-15 tire and a 26 x 6-inch USAF nylon-cord-ply tire. These two tires were tested for load-deflection data at different inflation pressures; however, interpolation and extrapolation of the data shown for the U. S. tire indicated that the MIG-15 tire had a higher deflection value for a given load up to about a 2.82-inch deflection at 100-psi inflation, and up to about a 3-inch deflection at 60- and 80-psi inflation, where a decided inversion again was indicated showing a lower deflection at a given load for the MIG-15 tire than for the U. S. tire.

a. Tread and Sidewall

Chemical analysis and infrared spectroscopy showed that the tread and sidewall of the casing were composed of a combination of GR-S and natural rubber. Calculations based on infrared absorption bands obtained for the tread and sidewall indicated a styrene content of about 13 per cent in the tread stock and about 15 per cent in the sidewall stock. These are average values determined by comparing a number of different spectral bands for styrene and natural rubber. A mixture of U. S. GR-S and natural rubber was used to obtain reference spectra; the U. S. GR-S stock contained approximately 75 per cent polybutadiene and 25 per cent styrene. At the time of this investigation, no information was available regarding the ratio of polybutadiene to styrene in the Soviet GR-S rubber; therefore, the percentage figures for the composition of the copolymers are, at best, only a "guesstimate". Calculations based on the average values for styrene and natural-rubber contents in the Soviet stocks indicated that the tread and sidewall samples contained a GR-S rubber which was composed of approximately 3 to 4 parts polybutadiene to 1 part styrene. Likewise, on the basis of these values, it was estimated that the tread and sidewall samples were composed of approximately 55 to 65 per cent GR-S and 35 to 45 per cent natural rubber. It should be noted that the greater the error in the calculated 3/1 polybutadiene/styrene ratio, the greater will be the error in the values calculated for the GR-S/natural-rubber contents of the Soviet materials. A literature survey had indicated that the Soviets are probably making a GR-S rubber having less than 20 per cent styrene. If this is so, then the ratio of GR-S to natural rubber in the tread and sidewall would be higher than noted above and would approach a value of approximately 75 per cent GR-S (butadiene-styrene) and 25 per cent natural rubber.

Carbon black was the principal filler used in the Soviet tread and sidewall rubber. The carbon black used appeared to be of fine particle size. The amounts of carbon black, approximately 35 and 30 per cent in the tread and sidewall stocks, respectively, were similar to the carbon-black content which is used in similar U. S. GR-S rubber stocks.

The ash contents of the two Soviet stocks were similar, about 3.5 per cent. Spectrographic analysis showed that zinc oxide was the major constituent (Table III). These values are equivalent to those found in similar U. S. compositions.

Adhesion of the tread to the adjacent fabric ply was 50 pounds of pull per inch width of sample. This value indicates good adhesion.

The tensile-strength values of 1,930 and 1,718 psi (average) for specimens from the Soviet tire-casing tread and sidewall, respectively, were considerably lower than that of about 2,700 psi reported for a typical U. S. GR-S passenger-car tread stock with a Rex durometer hardness of 70. Severe aging of the Soviet materials (seven days at 212 F) reduced the tensile strengths of both materials to about one-half of the original values. However, one area of this section of the casing had been damaged by fire, and aging of the entire casing section undoubtedly had been accelerated by this prior localized heating. Therefore, it should be kept in mind that the aging for seven days at 212 F represents only part of the total aging of this fire-damaged section of tire, and that the effect of any previous aging (during storage and during service) is unknown. It is also important to recognize that USAF specifications are determined on tires which are less than one year of age and have not been in service.

The ultimate-elongation values of 238 and 270 per cent for the Soviet tread and sidewall, respectively, compared favorably with the value of 310 per cent reported for typical U. S. GR-S tread rubber. The ultimate-elongation values for the samples after severe aging were very low, 63 per cent for the tread rubber and 33 per cent for the sidewall rubber.

Qualitative low-temperature flexibility tests resulted in very stiff specimens with a Rex hardness of 90 at -40 F, and specimens which were not flexible with a Rex hardness of 95 at -65 F. The aged specimens showed similar low-temperature properties. These test results indicated that the Soviet rubber samples probably would not meet USAF specifications for low-temperature properties of tire-casing tread and sidewall stocks; U. S. materials are required to withstand severe low-temperature flexibility and impact tests over the range 0 to -65 F.

The abrasion resistance of the Soviet tread and sidewall stocks was found to be about 93 and 103 per cent, respectively, when ASTM reference samples were used for comparison(1). These values are considered to be fairly good (abrasion resistance of a tread sample from an F-86 tire casing measured 107 per cent). The abrasion resistance of the aged samples, using unaged ASTM rubber specimens for comparison, was about 55 per cent for the tread rubber and about 51 per cent for the sidewall rubber. Again, before these very low values are used to grade the Soviet casing as inferior, consideration must be given to previous aging of the tire, in storage, possibly, and in service on the MIG-15 aircraft, as well as to the effect of the obvious fire damage on an area of the tire adjacent to the sampled area.

Rex durometer-hardness values for both tread and sidewall stocks increased from 67 for the unaged samples to 80 for the aged samples. This increase in hardness is somewhat higher than that commonly called for in U. S. specifications; an increase of 10 points is considered maximum for most U. S. stocks.

b. Cushion

Composition analysis and physical and mechanical properties of the Soviet tire-casing cushion are presented in Table II. Chemical analysis and infrared spectroscopy showed that the cushion was made of natural rubber. The principal filler was carbon black (30 per cent content). The ash content was 3.1 per cent and was mainly zinc oxide (Table III).

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(1) ASTM designation: D-394-47, Method A, using Standard C for comparison.

The cushion rubber had good low-temperature properties; it was very flexible at -40 and -65 F. The flexibility tests were made on a section of cushion which had fabric plies adhering to the top and bottom surfaces, since it was impossible to remove the plies from a section large enough for testing without greatly damaging portions of the cushion.

Due to surface conditions of the cushion and good adhesion of adjacent fabric plies (50 pounds per inch), it was not possible to prepare "dumbbells" for tensile specimens. Also, it was not possible to determine reliable durometer-hardness data.

c. Inner- and Outer-Ply Skim Coatings

Table II includes the results of chemical and infrared analyses and limited data on physical and mechanical properties for the inner- and outer-ply skim coatings of the Soviet-aircraft tire casing. The two skim coatings closely resembled each other in composition; both were made of natural rubber and the carbon black contents were 13.8 and 11.2 per cent for the inner-ply and outer-ply coatings, respectively. The ash contents were high (13.3 and 23.6 per cent for inner- and outer-ply coatings, respectively) and were composed mainly of zinc oxide.

Adhesion of the inner-ply skim coating to the adjacent fabric ply was 25 pounds per inch. This is fairly good inner-ply adhesion. The outer-ply skim coating showed only fair adhesion, 15 pounds per inch, when pulled from the adjacent cord ply on the Scott tester. The value of 15 pounds per inch corresponds to the lower limit of U. S. specifications for the adhesion of tire cords.

d. Bead Stocks

The Soviets had employed both bead-filler rubber and bead-insulation rubber in the bead construction. Table II shows the composition analysis for both of these components.

The bead filler was made of natural rubber having 27.8 per cent carbon black filler and 5.1 per cent ash content. The main constituent of the ash was zinc oxide. Natural rubber of like composition is used in the U. S. for similar elements of aircraft tire casings.

The bead-insulation rubber was polybutadiene with 23.8 per cent carbon black as the main filler and 6.0 per cent ash, consisting mainly of magnesium silicate. U. S. practice is to use natural or GR-S rubber for this application. However, the use of polybutadiene appeared to be satisfactory.

e. Bead Wire

Two different sizes of wire, 0.038 and 0.018 inch in diameter, from the inner and outer beads of the tire casing were examined for quality. The wires were not plated; in U. S. practice, copper is sometimes employed as plating material for bead wires. Spectrographic analysis showed that both sizes of wire were made of similar plain carbon steel. Metallographic examination revealed that the steel was of medium carbon content (about 0.40 to 0.60 per cent carbon). Also, the steel was of good quality, showing very few nonmetallic inclusions. Both sizes of wire had been drastically cold worked. The 0.033-inch-diameter wire showed evidence of more cold work than did the 0.013-inch-diameter wire.

Vickers hardness and tensile tests on the two sizes of wire showed the following:

Diameter, in.	Vickers Hardness Number	Bead Estimated Tensile Strength, psi	Actual Tensile Strength Per Wire, psi
0.018	473	223,000	-
0.038	534	252,000	253,000

The 0.018-inch-diameter wire was too distorted and twisted from use in the bead to permit determination of the tensile strength. The 0.033-inch wire with a tensile strength of 253,000 psi is considered satisfactory in the U. S. for use in aircraft tire casings.

f. Tire Cord Fabric

Fabrics used in cord plies, bead wraps, and chafing strips of the tire casing were identified by means of the polarizing microscope, using standards as suggested in ASTM Standards on Textile Materials. Some chemical tests were employed, as required for substantiation of the microscopic identification.

The bead-wrap fabric and the chafing-strip fabric were identified as cotton. The composition of the cord removed from the fabric plies was conclusively shown to be nylon or nylon-type fiber; the solubility test in phenol was positive. As a matter of interest, it has been reported[1] that a large portion of East Germany's production of perlon (a nylon-type fiber) is being shipped to the U.S.S.R. for use in jet-aircraft tires.

(1) SO-36905, "Manufacture of Perlon", CIA, 1951, F-3 (SECRET).

Visual and laboratory examinations of the nylon-type cord showed the following characteristics:

1. The cord consisted of a 2-ply, ZZS twist with 10 turns per centimeter (25.4 turns per inch).
2. The 2-ply cord, or cable, measured 0.81 mm (0.032 inch) in diameter. A single ply measured 0.48 mm (0.018 inch) in diameter. Single-filament measurements varied over a range of 15 to 25 microns in diameter. The majority of the filaments measured 20 microns in diameter.
3. The filament count of one ply numbered 286; the other ply contained 268 filaments.
4. Tensile-strength values averaged 11 pounds for a single ply and 26 pounds for the 2-ply cord.

A comparison of these findings with data on similar U. S. nylon cord used in fabric plies of aircraft tire casings indicated that:

1. The Soviet cord construction was similar to U. S. nylon cord construction.
2. The Soviet cord gage was somewhat larger than that of nylon cord used similarly in the U. S.
3. The Soviet cord tensile-strength values compared favorably with those of nylon cord used in fabric plies of U. S.-aircraft tire casings.

SP/DMcN:rws

January 22, 1953

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DEPARTMENT OF THE AIR FORCE
WASHINGTON, DC

23 June 2010

HAF/IMIO (MDR)
1000 Air Force Pentagon
Washington, DC 20330-1000

Bobby Sammons.
P.O. Box 1680
Cloudcroft, NM 88317-1680

Dear Mr. Sammons

Reference to your letter, undated (attachment 1) requesting a Mandatory Declassification Review (MDR) for Defense Technical Information Center (DTIC) documents:

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AD005808	AD004232

The review for the documents have been completed and the declassification has been downgraded to UNCLASSIFIED and copies are attached for your information.

Address any questions concerning this review to the undersigned at (703) 692-9979 and refer to our case number 07-MDR-076.

Sincerely

JOANNE MCLEAN
Mandatory Declassification Review Specialist

2 Attachments
1. Letter, Request for Documents
2. 10 DTIC Documents

cc: DTIC w/o documents