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AMRL-TR-67-58

IDENTIFICATION OF VOLATILE CONTAMINANTS OF SPACE CABIN MATERIALS

J. V. PUSTINGER, JR.
F. N. HODGSON

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The general analyses of the gas-off products by gas chromatography were performed on an F&M Model 810 Research Gas Chromatograph equipped with dual flame ionization detectors. In most cases, a general purpose double column, 20-ft x 0.25-in. ss. 5% Carbowax 20M on 60/80 mesh Gas Pack F with a pre-column of 12-ft x 1/8-in. ss. 7% neopentylglycolsuccinate on 60/80 mesh Gas Pack F (temperature programmed 50-185°C at 10°C/min) was used because of its excellent partitioning properties for both polar and nonpolar compounds. The pre-column of neopentylglycolsuccinate provided a liquid system to aid in partitioning the sample at temperatures at which the Carbowax 20M section was still solid. Other columns were employed as needed.

Quantitative gas chromatography data were obtained by comparing the peak heights with those of a standard mixture. Gas chromatographic instrument conditions are presented in Appendix 11, Table XXCV.

Identifications of gas chromatographic fractions were made by collecting components from the effluent gases and by subsequently characterizing them with mass spectrometry or infrared spectrophotometry. Fractions were isolated by splitting the effluent gases to permit a small percentage (10%) to pass through the flame ionization detector and to direct the rest through the trapping system. Most of the components were isolated by using glass capillaries that were packed with 5% Carbowax 20M on 60/80/mesh Gas Pack F substrate and cooled to -195°C (Fig. 1).

b. Mass Spectrometric Analysis of Gas-Off Products

Mass spectrometric analyses were performed by taking an aliquot (125 ml) of the atmosphere of the 9-liter bottle (Ref. 1). Measurements were made with a Consolidated Electrodynamics Corporation Model 21-103C Mass Spectrometer,

Identifications of individual components were made by mass spectrometry and were supported by infrared absorption and by gas chromatographic data as needed. Most of the mass spectra obtained were compared to API (American Petroleum Institute) reference spectra. In cases where the requfred mass spectrum does not appear in the API collection, comparison was made with spectra from our laboratory files or from the literature.

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Table II

TYPES OF COMPOUNDS .DETECTED

I. Inorganics

Ammonia
Carbon Monoxide

11. Alkanes

C_2 Hydrocarbon(s)
C_4 Hydrocarbon(s)
C_5 Hydrocarbon(s)
C_6 Hydrocarbon(s)
C_7 Hydrocarbons
C_8 Hydrocarbon
C_9 Hydrocarbons
C_{10} .Hydrocarbons
Methane
3-Methylhexane

111. Alkenes

Butene
Dimethylbutene
Ethylene
Methylbutene(s)
C_5 Unsat. Hydrocarbons
C_6 Unsat. Hydrocarbons
C_7 Unsat. Hydrocarbons
C_8 Unsat. Hydrocarbons
C_9 Unsat. Hydrocarbons
C_{10} Unsat. Hydrocarbons
Isobutylene
Methylpropene
Trichloroethylene
Tetrafluoroethylene
Trimethylhexane
Trimethylhexadiene(s)

Table II - Continued

IV. Alcohols

n-Butanol
2-Butanol
sec-Butanol
tert-Butanol
2-(2-Butoxybutoxy) Ethanol
2-n-Butoxy Ethanol
Diacetone Alcohol
Ethanol
2-Ethoxyethanol
2-(2-Ethoxyethoxy) Ethanol
Isopropanol
Mesityl Oxide
Methanol
2-Methoxyethanol
2-Methyl,1-butanol
2-Methyl,2-butanol
2-Methyl,1-propanol
2-Methyl,2-propanol
2-Phenyl,2-propanol
n-Propanol

V. Alkyl Halides

Chloroform
Homologous Series of Chloro-fluorocarbons
Methylene Chloride
1,1,1-Trichloroethane
Trichlorofluoromethane

VI. Carboxylic Acids and Their Derivatives

Acetic Acid
2-(2-Butoxybutoxy) Ethyl Acetate
2-n-Butoxyethyl Acetate
y-Butyrolactone
2-(2-Ethoxyethoxy) Ethyl Acetate
2-Ethoxyethyl Acetate
Ethyl Acetate
High M.W. Ethoxy Carboxylic Acid Esters
Methyl Tiglate
Tiglic Acid

Table II - Continued

VII. Aldehydes

Benzaldehyde
Butyraldehyde
2-Furaldehyde
2-Methyl,2-butenal

VIII. Ketones

Acetone
Acetophenone
2-Butanone
Methyl Cyclohexanone
4-Methyl,2-pentanone

IX. Ethers

Diethyl Ether
1,3-Dioxalane
1,4-Dioxane
Epichlorohydrin
Ethylene Oxide
N-Methyl Morpholine

X. Aliphatic Nitrogen Compounds

Dimethylamine
Nitromethane

XI. Cyclic Hydrocarbons

Cyclohexane

XII. Benzene and Its Homologs

C_3 Alkyl Benzene(s)
C_4 Alkyl Benzene(s)
C_5 Alkyl Benzene(s)
Benzene
Ethyl Benzene
Methyl Ethyl Benzene
Phenyl Pentane
Toluene
Xylene

Table II - Continued

XIII. Aryl Halides

Dichlorobenzene

XIV. Aromatic Hydroxy Compounds

Phenol

XV. Aromatic Acids and Their Derivatives

2,4-Dichlorobenzoic Acid

XVI. Silicon Compounds

Trimethyl Silanol
Various Cyclic and Linear Methylsiloxane Polymers

Table III

CANDIDATE MATERIALS FOR WHICH CARBON MONOXIDE IS THE ONLY GAS-OFF PRODUCT

Candidate Material	AF Serial No.	Weight Carbon Monoxide (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Phenolic Resin, Durez 12810	019	0 03	N D	N D	0 002
Polyamide, zytel 42	039	0 02	N D	N D	N D
Polyamide, PH880009, Type RT 40	108	0 006	0 007	0 004	0 007
Epoxy/Glass, Scotch Ply 1002	238	0 008	0 003	0 006	0 002
Teflon Sheet, Teflon	249	0 004	0 003	0 001	N D
(No Identification)	207	0.06	0.009	0 01	0 04
(No Identification)	247	0.03	N.D.	0 01	0 002
Receptacle, DS07-375	111	0.03	N.D.	(Tests not made)	
Lubricant, Aroclor 1254	301	0.003	N.D.	N D	N D
Polyethylene Film	326	0.003	N.D.	N D	N D
Finish Black Filling Compound, Rhoplex Black Filler	335	0.3	0.03	0 05	0 06
PFE, No 25495	340	0.007	N.D.	0.003	0.003
Adhesive, Eccobond 26	352	0.3	0.006	0.004	0.008
Thermoset Plastic, Eccobond 56C	353	0.06	0.01	0.01	0.03
Thermoplastic, Lockfoam C-608	359	0.02	0.005	0.007	0.007

N D = Not Detected

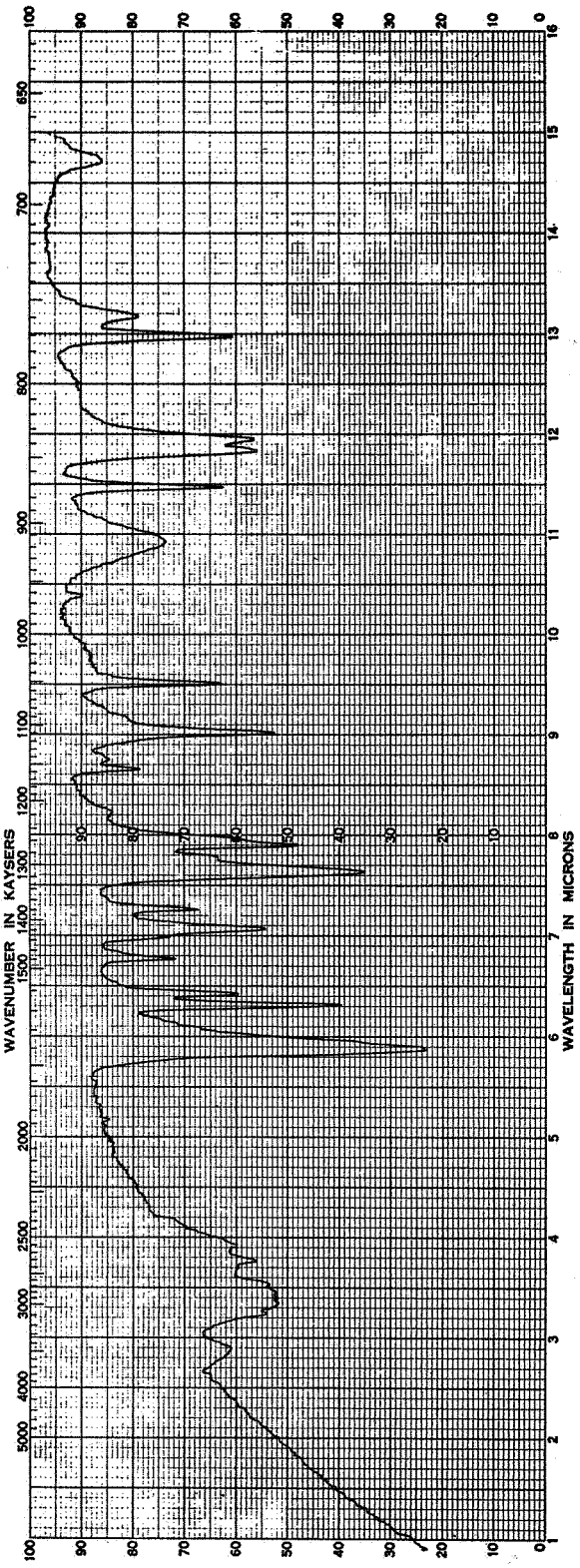

Figure 2 Infrared Spectrum of Crystals from Silicone, Silastic 651 (AF 245) (KBr pellets).

Hydrocarbons are frequently listed only by carbon number. From observations of the chromatograms, it will be noted that a hydrocarbon of a given carbon number may have any one of a variety of retention times. The approximate order in which hydrocarbons elute with the particular column configuration used for this study is: aliphatic saturated hydrocarbons first, then aliphatic unsaturates, cyclic saturates, and, finally, cyclic unsaturates. Of course, the degree of branching also influences the retention time.

There are several other cases where the gas-off products are calculated collectively. During gas-off studies (Ref. 1) in the past, a series of volatile linear and cyclic siloxane polymers (having dimethyl siloxy groups as monomer units) have been observed from certain silicone base materials. This volatile portion is listed in the tables simply as silicone oil.

The candidate material, Fluorolub Oil FS-5 (AF 305), gave gas-off products composed of chlorofluorocarbons of various chain lengths. A value for the total amount of these gas-off products that are present is reported.

SECTION III

ANALYSES OF BIO-ENVIRONMENTAL ATMOSPHERES

A portable system for cryogenic trapping of atmospheric contaminants from bio-environmental chambers was constructed to be used at Wright-Patterson Air Force Base. Front and back views of the system are shown in Figures 4 and 5. For on-site use, the Welch Duo-Seal vacuum pump (shown in Figures 4 and 5) was replaced with a Bell & Gossett, Inc. high-volume oil-less vacuum pump. Typical Pyrex traps (fitted with quartz baffles) that are used with the cryogenic system are shown in Figure 6. Contaminants are collected at three different temperatures [0°, -76°, and -175° (or -195°C)] by passing the atmospheric gas of the chamber serially through the traps.

Bio-environmental Sample No. 1 was collected from Thomas Dome No, 4. Thomas Dome No, 4 housed dogs and monkeys at 5-psia oxygen, The coolants used in the three traps of the collection train were ice-water, dry ice-methylene chloride, and liquid nitrogen. Twenty liters of air were drawn through the trapping system at the rate of 150 ml/min. In addition, a specimen of air from the dome was collected for the analysis of noncondensible gases. An analysis of the dome atmosphere is given in Appendix III, Table XXCVI.

A solid white material from Bio-environmental Sample No. 1, collected in the ice water trap, was identified as a mixture of ammonium compounds that were tentatively characterized for the most part as ammonium sulfate, sulfite, and/or bisulfate. No lithium carbonate was detected.

Methylene chloride, which was found in the traps, at first was thought to be the product from a slight leak which allowed the methylene chloride from the dry-ice trap to enter the trap manifold. However, since the compound was also present in the sample of untrapped air, it is believed to actually be present in the dome atmosphere.

Bio-environmental Sample No. 2 consisted of a cylinder of contaminated aviator's breathing oxygen. The identity of contaminants which caused nausea were sought. Two impurities were found and are listed in Appendix III, Table XXCVII.

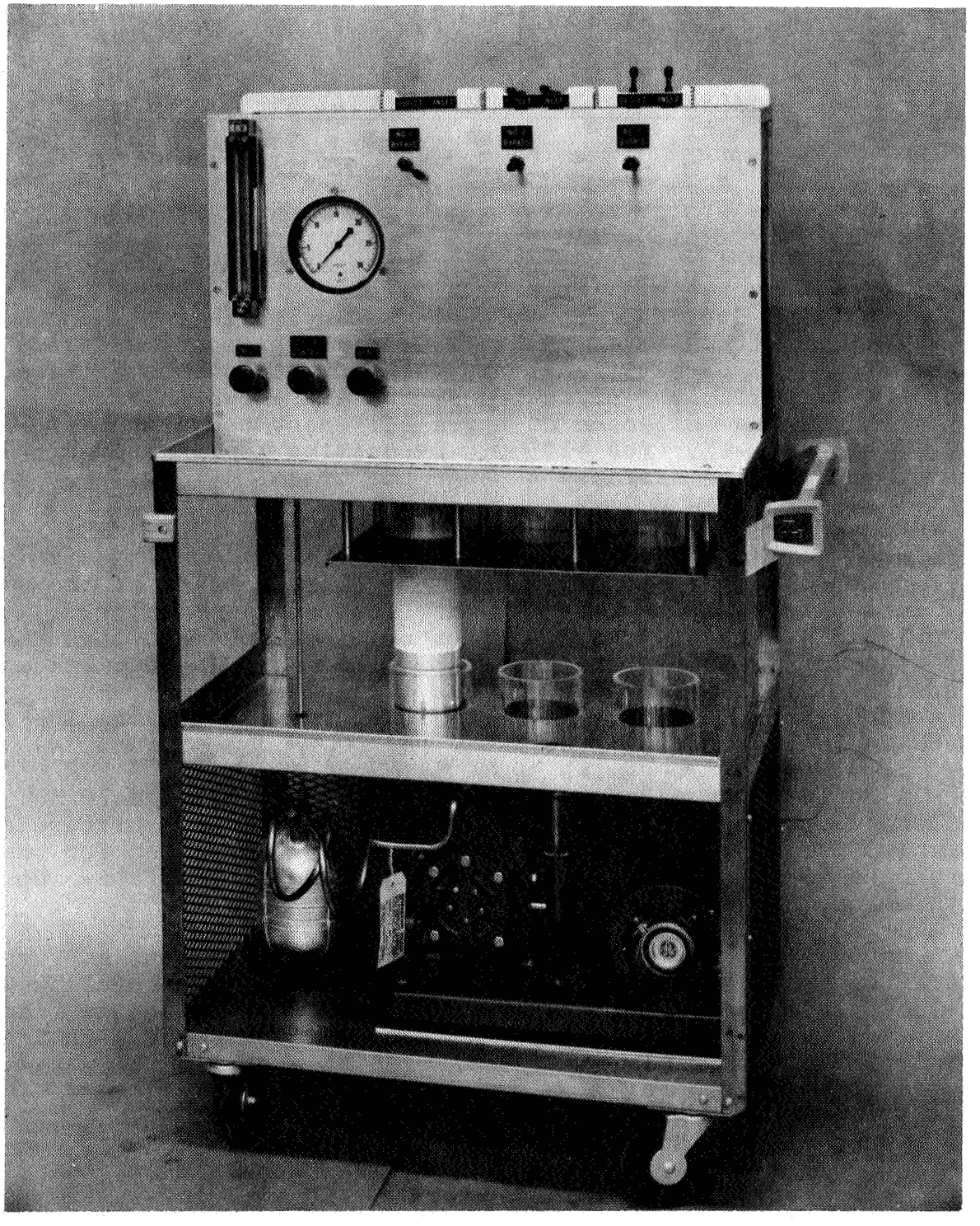

Figure 4. Cryogenic Trapping System for Bio-environmental Experiments (Front View).

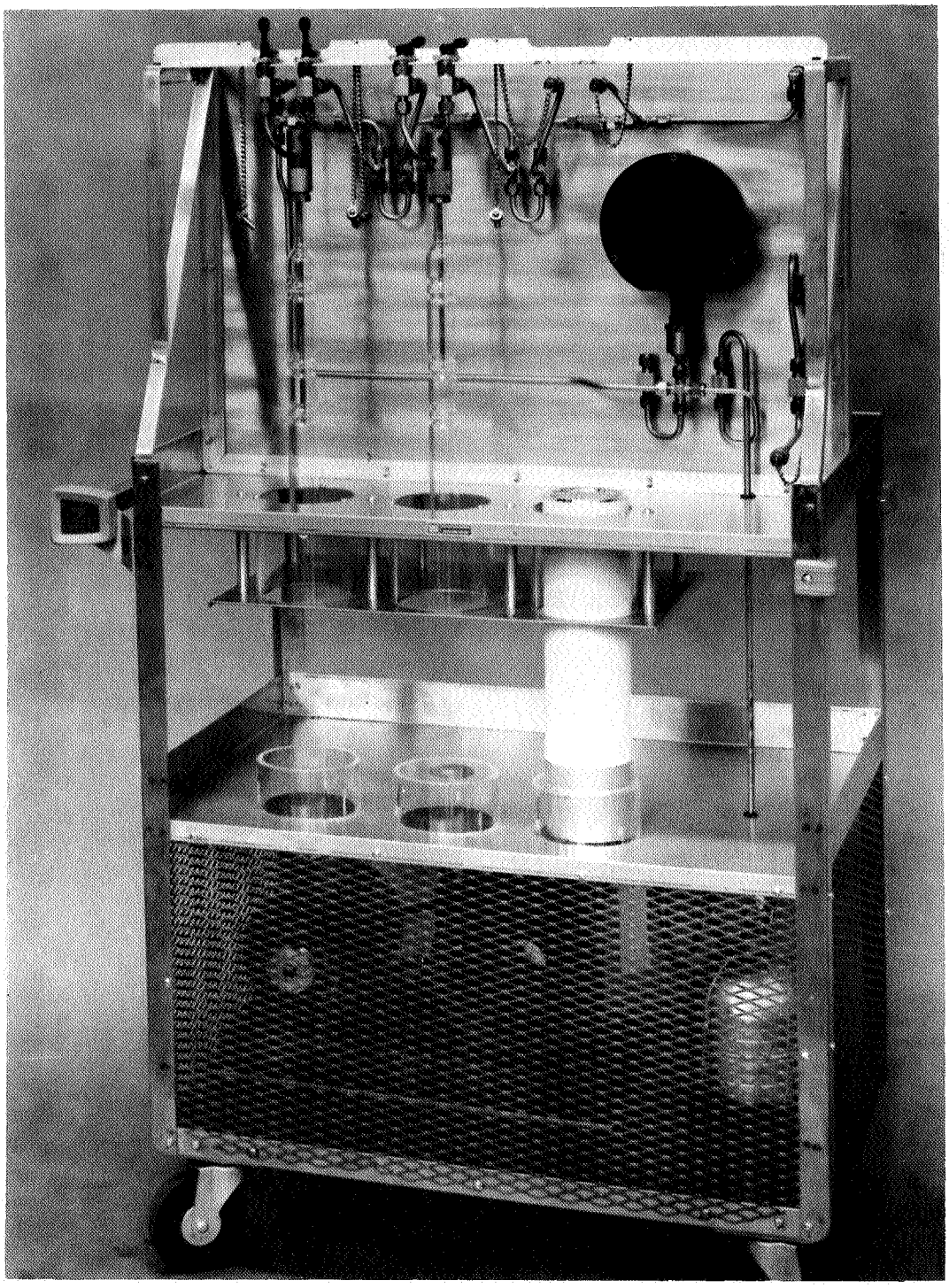

Figure 5. Cryogenic Trapping System for Bio-environmental Experiments (Rear View).

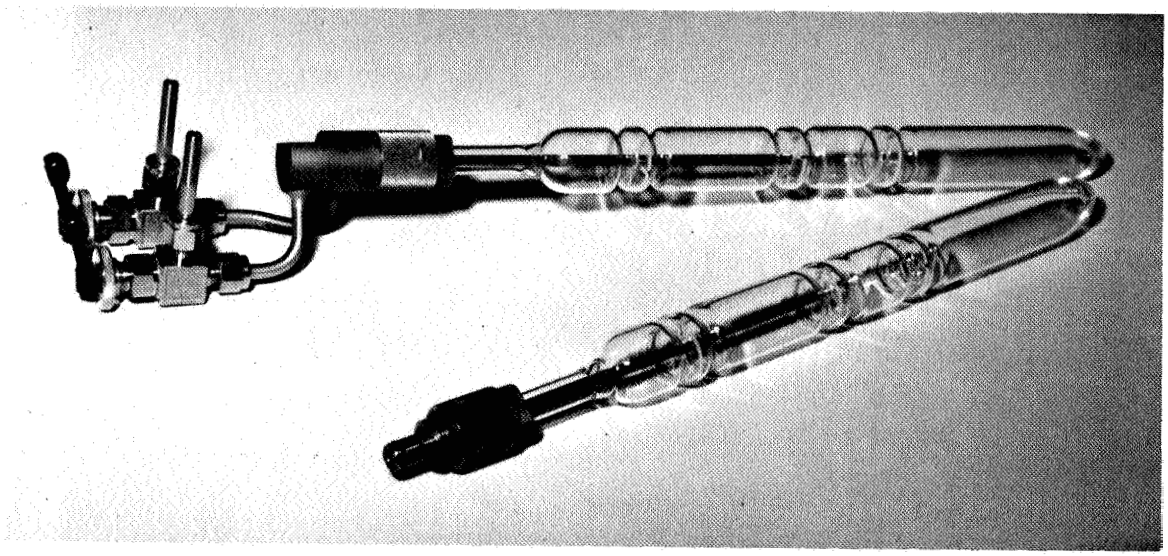

Figure 6. Pyrex Traps and Attachments Used with Cryogenic Trapping System.

Bio-environmental samples No. 3 and No. 4 were collected from the atmosphere of a test chamber in which an accidental spill of the functional fluid, Hydrotherm 700B (composed of mixed C_8 silicates, e.g., n-octyl and ethylhexyl silicates) had occurred.

In Sample No. 3 (the first specimen collected from the chamber) two of the components were the same as those of the products obtained by hydrolysis of the functional fluid. In addition, a third component (trichloroethylene) was detected.

Sample No. 4 was collected from the chamber after the chamber had been flushed with air. The same components (but at a much lower level) that were found in Sample No. 3 were detected in Sample No. 4. Data for Samples No. 3 and No. 4 are shown in Appendix III, Table XXCVIII.

SECTION IV

CONCLUSIONS

Gas-off products from cabin materials are not mysterious fumes, but are, mostly, commonplace chemicals. As expected, the major yields of gas-off products occur with the paint and coating candidates, which desorb entrapped solvents and plasticizers. Lesser, yet significant amounts of contaminants result from oxidation, hydrolysis, and sublimation processes.

Even after pretreatment at 25°C and 0.1 torr, considerable amounts (up to 80 mg/10 grams of candidate material) of gas-off products have been detected from materials (such as coatings, paints, and adhesives) that were prepared immediately prior to testing. In most cases, larger amounts of contaminants are observed after 14 days at 68°C, than are observed after 30, 60, and 90 days at 25°C.

Surprisingly high levels of carbon monoxide have been observed for some materials when stored for 14 days at 68°C. In some cases, extremely large increases (200-fold) in the carbon monoxide level were observed when the storage temperature was raised from 25°C to 68°C.

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Table XXI

GAS-OFF PRODUCTS FROM THINNER, CONAP 1046 AND S-1

AF Serial No. 035

Component	Weight of Component (mg/10 gms Candidate Mate) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Acetone	10	3.1	3 5	0 4
Isopropanol	190	220	240	190
n-Propanol	10	N.D.	5 3	4 4
Toluene	110	110	120	90
Xylene	0.3	N.D.	0.1	0.2
Methyl Cyclohexanone	0.2	0.07	0.08	0.08
Carbon Monoxide	0.03	0.001	0.01	0.01
Methane	N D.	N.D.	0.005	0.02

N D = Not Detected

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Table XXV

GAS-OFF PRODUCTS FROM INK, MM 7133 FP

AF Serial No. 042

Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
C_5 Hydrocarbon(s)	0 8	0.3	0 5	0.5
C_4 Hydrocarbon(s)	0.9	0.4	0.8	0.7
Acetone	7.3	5.3	7.8	7.2
Butyraldehyde	8.3	3.3	4.8	4.7
2-Butanone	0.05	0.03	0.2	0.2
Benzene	0.7	0.3	0.3	0.4
n-Propanol	9.7	3.5	4.7	4.7
4-Methyl,2-pentanone	2.5	1.8	2.9	2.5
Toluene	0 02	0.03	0.1	0.04
n-Butanol	0.9	1.3	1.8	1.2
Ethyl Benzene	0.1	0.02	0.2	0.08
Methyl Ethyl Benzene	0 05	0.05	0.05	0.06
C_3 to C_4 Alkyl Benzenes	0.2	0.2	0.2	0.2
Carbon Monoxide	29	11	16	21
Methane	0.9	0 09	0 3	0 3

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Table XLIV

GAS-OFF PRODUCTS FROM POLYURETHANE, STAFOAM AA604

AF Serial No. 120

Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Acetone	N D	0 007	N D	N.D.
Toluene	0 3	0.05	0 007	0.007
Xylene	0 01	0 02	N D	N.D.
Carbon Monoxide	0 009	N D	N.D.	0.004
Methane	0 02	0 02	N.D.	0.01

N D = Not Detected

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Table XLIX

GAS-OFF PRODUCTS FROM POLYESTER/GLASS 1304/161

AF Serial No 130

Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Acetone	0.06	N.D	N.D.	N.D.
2-Propanol	0.2	0.2	0.04	0.04
2-Methyl-2-propanol	0.5	0.09	0.1	0.1
Benzene	0.03	N.D.	N.D.	N.D.
n-Propanol	0.003	N.D.	N.D.	N.D.
2-Butanol	0.09	0.009	0.02	0.02
n-Butanol	0.01	N.D.	N.D.	N.D.
Xylene	0.003	N.D.	N.D.	N.D.
Carbon Monoxide	0.09	N.D.	0.004	0.004
Methane	0.02	N.D.	N.D.	N.D.

N.D. = Not Detected

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Table LXVI

GAS-OFF PRODUCTS FROM THERMAL INSULATION, MIN-K503

AF Serial No. 244

Com Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Benzene	N D	0 002	N D	0 003
Toluene	0 001	0 005	0 005	0 005
Xylene	0 002	0 005	N D.	0 002
Carbon Monoxide	0 04	0 004	0 002	N D
Methane	N D	N D	N D	0 007

N D = Not Detected

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Table LXXI

GAS-OFF PRODUCTS FROM PHENOL RESIN/MOLYB DISULE, EVERLUBE 620

AF Serial No. 308

Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Acetone	0.09	N.D.	N D.	N.D.
Ethanol and 2-Propanol	5.0	N.D.	N D	0.06
Benzene	N.D.	N.D.	N.D	0.06
n-Propanol	N.D.	N.D.	0.07	0.2
Toluene	0.08	N.D.	N D	0.02
n-Butanol	0.02	N.D.	N.D	N.D.
Xylene	0.09	N.D.	N.D.	0.005
Carbon Monoxide	0.1	N.D.	0.005	0.005

N D. = Not Detected

Table LXXII

GAS-OFF TR

AF Aerial No 309

Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Methanol	0.2	N.D.	N.D.	0.09
Ethanol and Isopropanol	6.1	0.02	0.03	0.3
sec-Butanol	0.3	N.D.	0.01	0.3
Toluene	0.6	0.01	0.006	0.2
n-Butanol	32	1.1	2.0	21
Xylene	4.6	0.3	0.5	17
C_3 Alkyl Benzene	2.8	0.05	0.1	11
2-Ethoxy Ethyl Acetate	25	3.7	6.0	2
2-n-Butoxy Ethanol	0.08	N.D.	N.D.	0.08
2-(2-Ethoxyethoxy) Ethanol	0.03	N.D.	N.D.	0.03
Carbon Monoxide	0.06	N.D.	0.003	0.02
Methane	N.D.	N.D.	0.001	0.005

N D = Not Detected

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Table LXXIV

OFF PRODUCTS FROM PAINT, SILVER CONDUCTIVE

AF Serial No 312

Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Ethanol and Isopropanol	0.03	N.D.	N.D.	0.03
n-Propanol	0.01	N.D.	N.D.	N.D.
Toluene	0.003	N.D.	N.D.	N.D.
2-Methyl,2-butanol	0.01	N.D.	N.D.	0.1
n-Butanol	0.03	N.D.	N.D.	0.02
Xylene	0.01	N.D.	0.005	0.002
2-Ethoxy Ethyl Acetate	1.3	1.0	0.7	3.9
2-n-Butoxy Ethanol	0.05	N.D.	N.D.	0.03
2-(2-Ethoxyethoxy) Ethanol	0.003	N.D.	N.D.	0.01
2-(2-Ethoxyethoxy) Ethyl Acetate	0 01	N D	N D	0 02
Carbon Monoxide	0 03	0 007	0 002	N D

N D = Not Detected

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Table XXCI

GAS-OFF PRODUCTS FROM CEMENT, CLINCO NO_2,C,242

AF Serial No 336

Component	Weight of Component (mg/10 gms Candiate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Acetone	N.D.	N.D.	N.D.	0.006
Ethanol	0.03	0.03	0.02	0.009
Benzene	0.01	0.004	N.D.	0.006
n-Propanol	N.D.	N.D.	N.D.	0.005
sec-Butanol	0.02	0.09	0.1	0.3
n-Butanol	0.02	0.02	0.02	0.04
Xylene	0.02	0.04	0.04	0.1
C_3 Alkyl Benzene	0.03	0.02	0.02	0.07
Carbon Monoxide	0.2	0.01	0.01	0.02
Methane	0.004	N D	N D	N D

N = Not Detected

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Table XXCIII

GAS-OFF PRODUCTS FROM CANDIDATE MATERIAL

AF Serial No 358

C Component	Weight of Component (mg/10 gms Candidate Material) 14 Days (68°C)	30 Days (25°C)	60 Days (25°C)	90 Days (25°C)
Acetone	0 03	N D	N D	0 008
Benzene	0 02	0 2	0 3	0 3
Toluene	0 009	0 02	0 04	0.04
Carbon Monoxide	0 1	0 01	0 003	N D
Methane	0 01	0 03	N D	N D

N D = Not Detected

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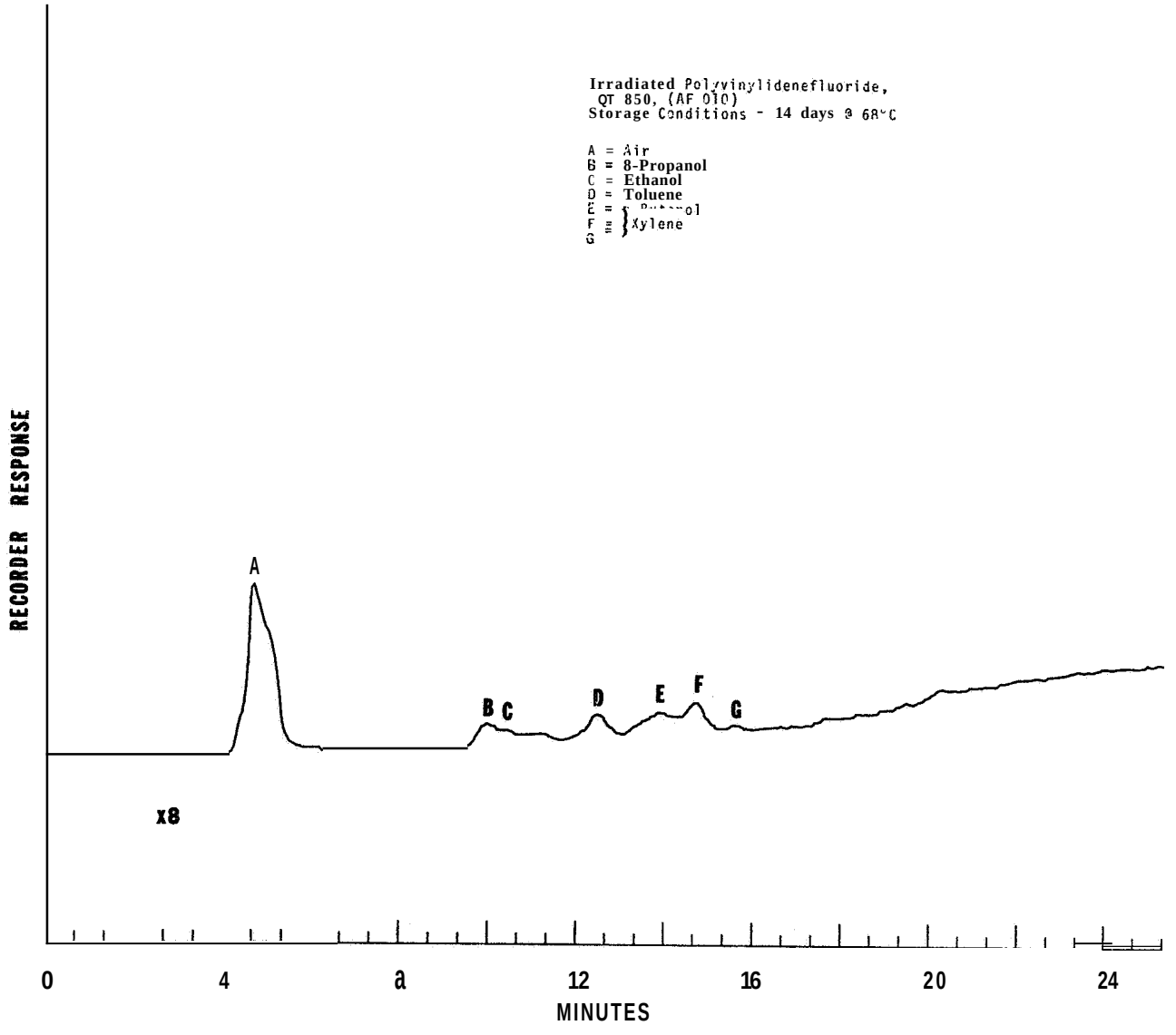

Figure 10. Gas Chromatogram of Gas-Off Products from Irradiated Polyvinylidenefluoride, RT 850 (AF 010) (14 days @ 68°C).

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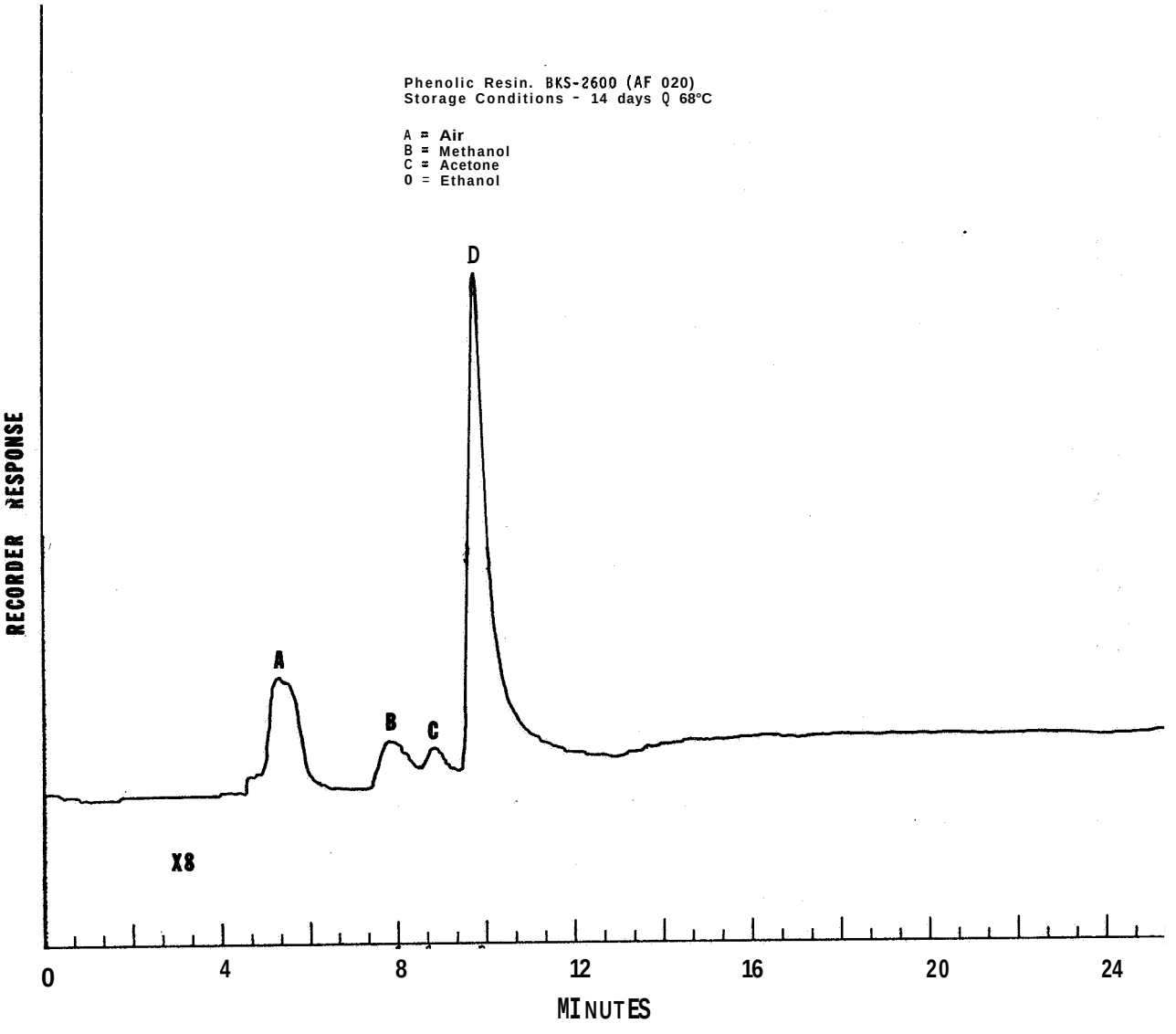

Figure 16. Gas Chromatogram of Gas-Off Products from Phenolic Resin, BKS-2600 (AF 020) (14 days @ 68°C).

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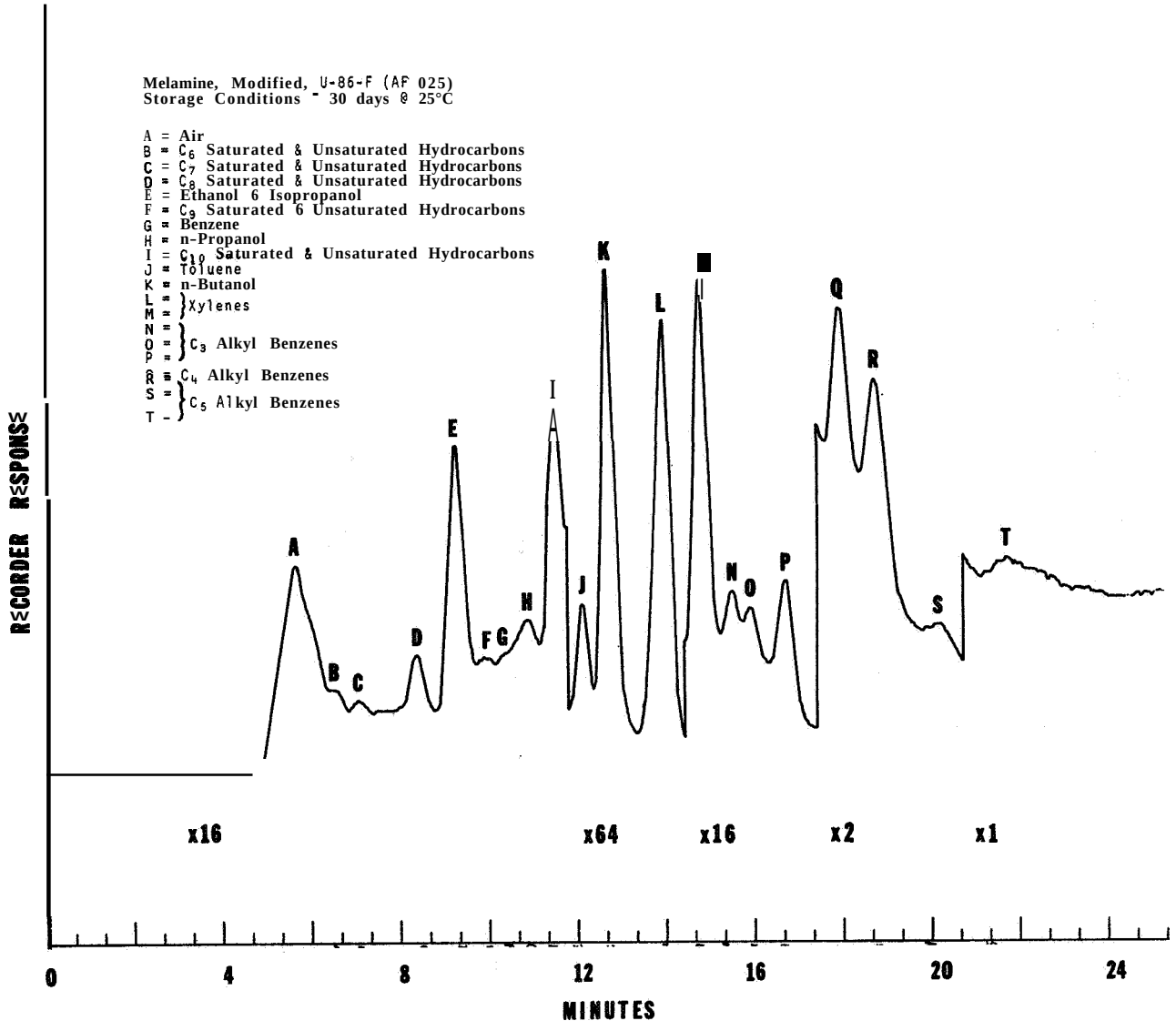

Figure 18. Gas Chromatogram of Gas-Off Products from Melamine, Modified, U-86-F (AF 025) (30 days @ 25°C).

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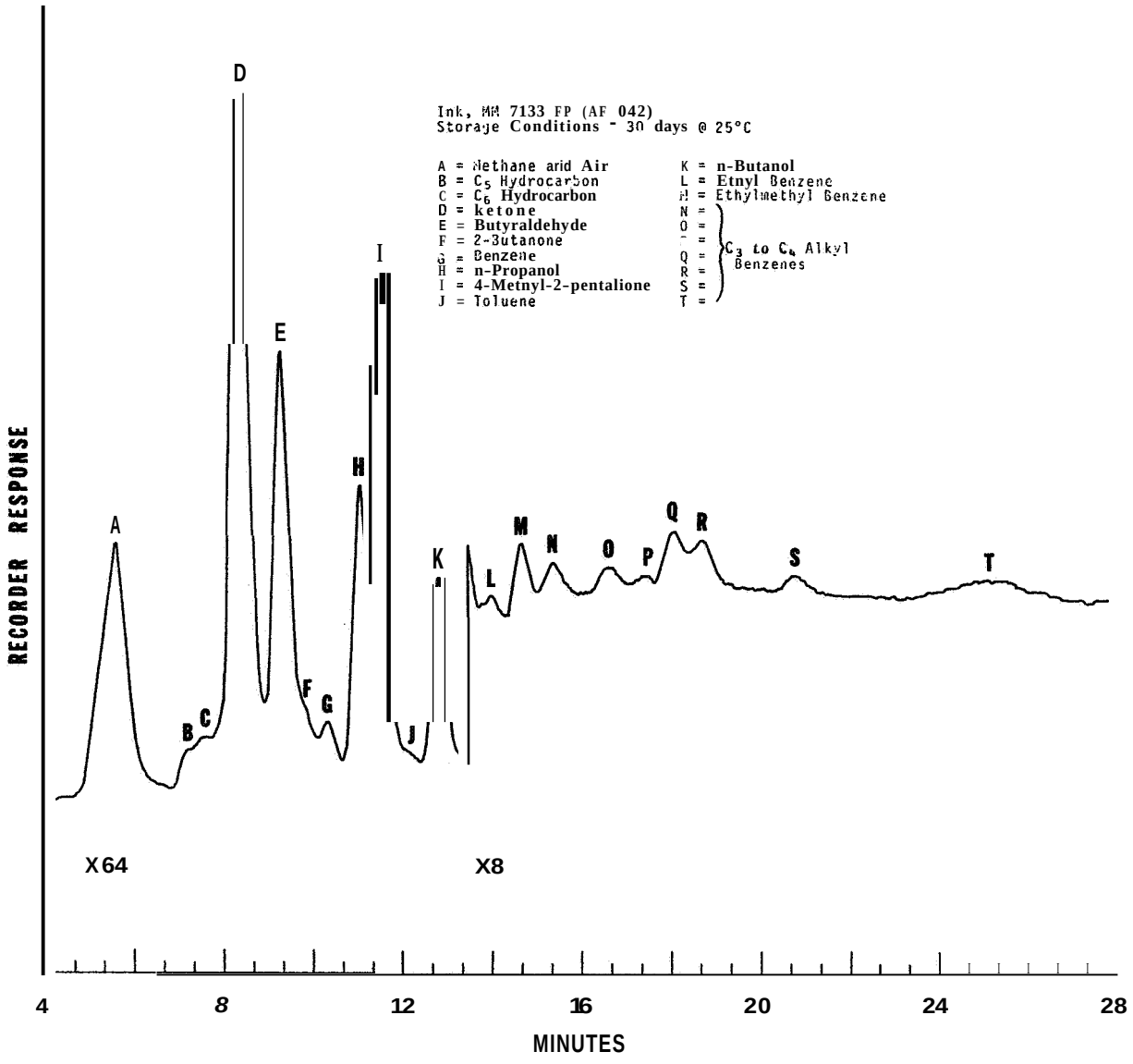

Figure 28. **Gas Chromatogram of Gas-Off Products from Ink, MM 7133 FP (AF 042) (30 days @ 25°C).**

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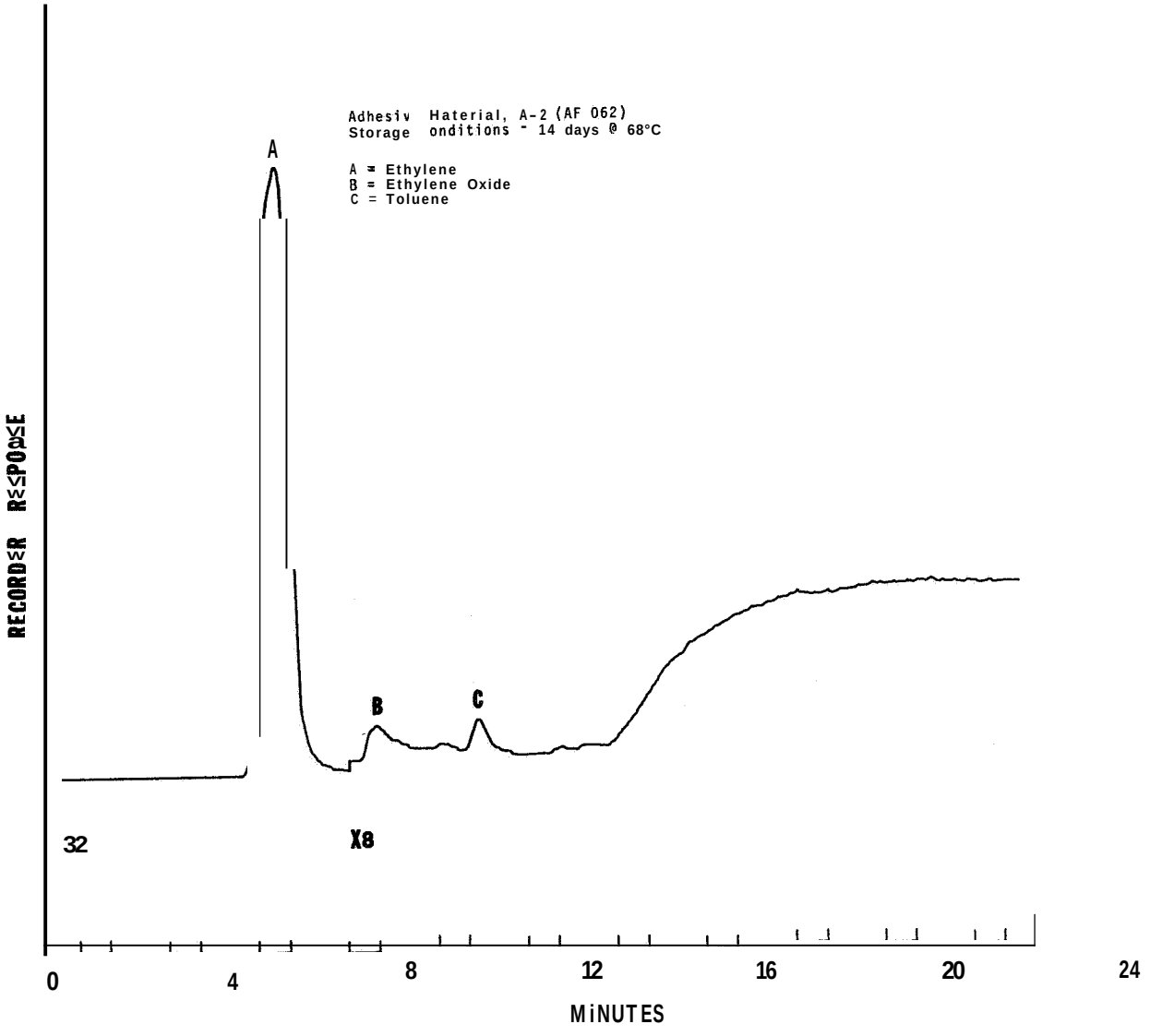

Figure 34. Gas Chromatogram of Gas-Off Products from Adhesive Material, A-2 (AF 062) (14 days @ 68°C).

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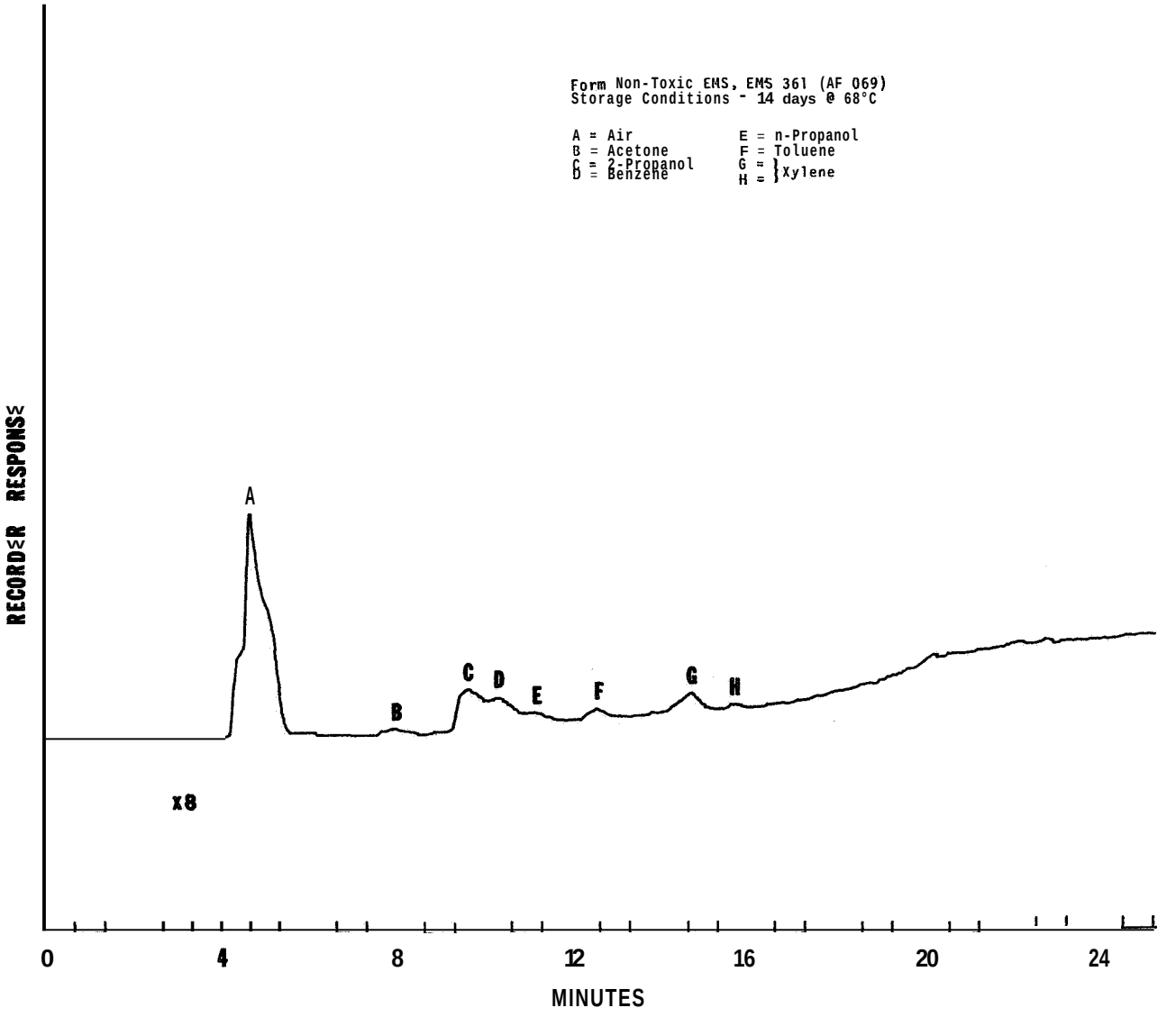

Figure 36. Gas Chromatogram of Gas-Off Products from Form Non-Toxic **EMS, EMS** 361 (AF 069) (14 days @ 68°C).

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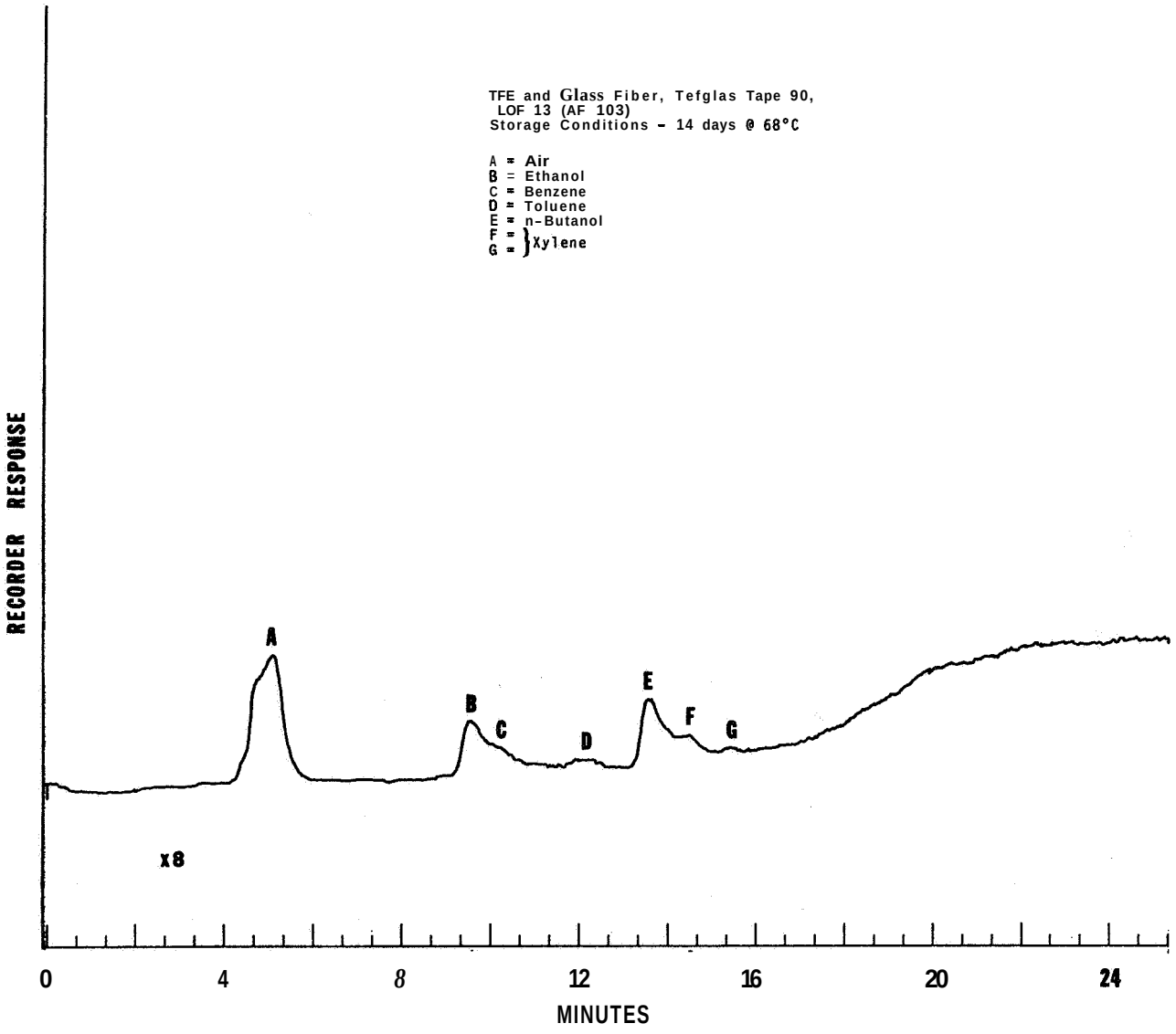

Figure 39. Gas Chromatogram of Gas-Off Products from TFE and Glass Fiber, Tefglas Tape 90, LOF 13 (AF 103) (14 days @ 68°C).

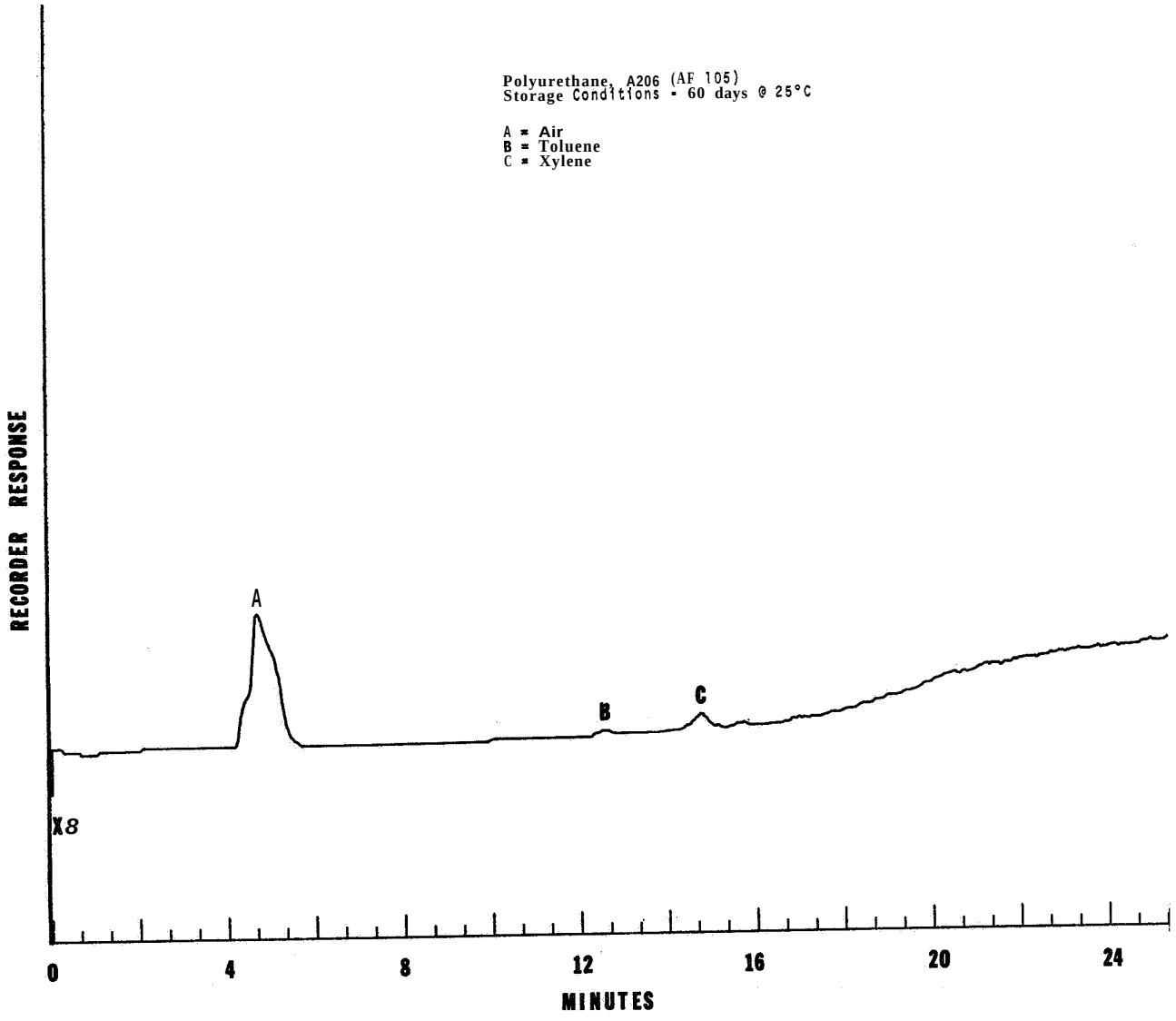

Figure 40. Gas Chromatogram of' Gas-Off Products from Polyurethane, A206 (AF 105) (60 days @ 25°C).

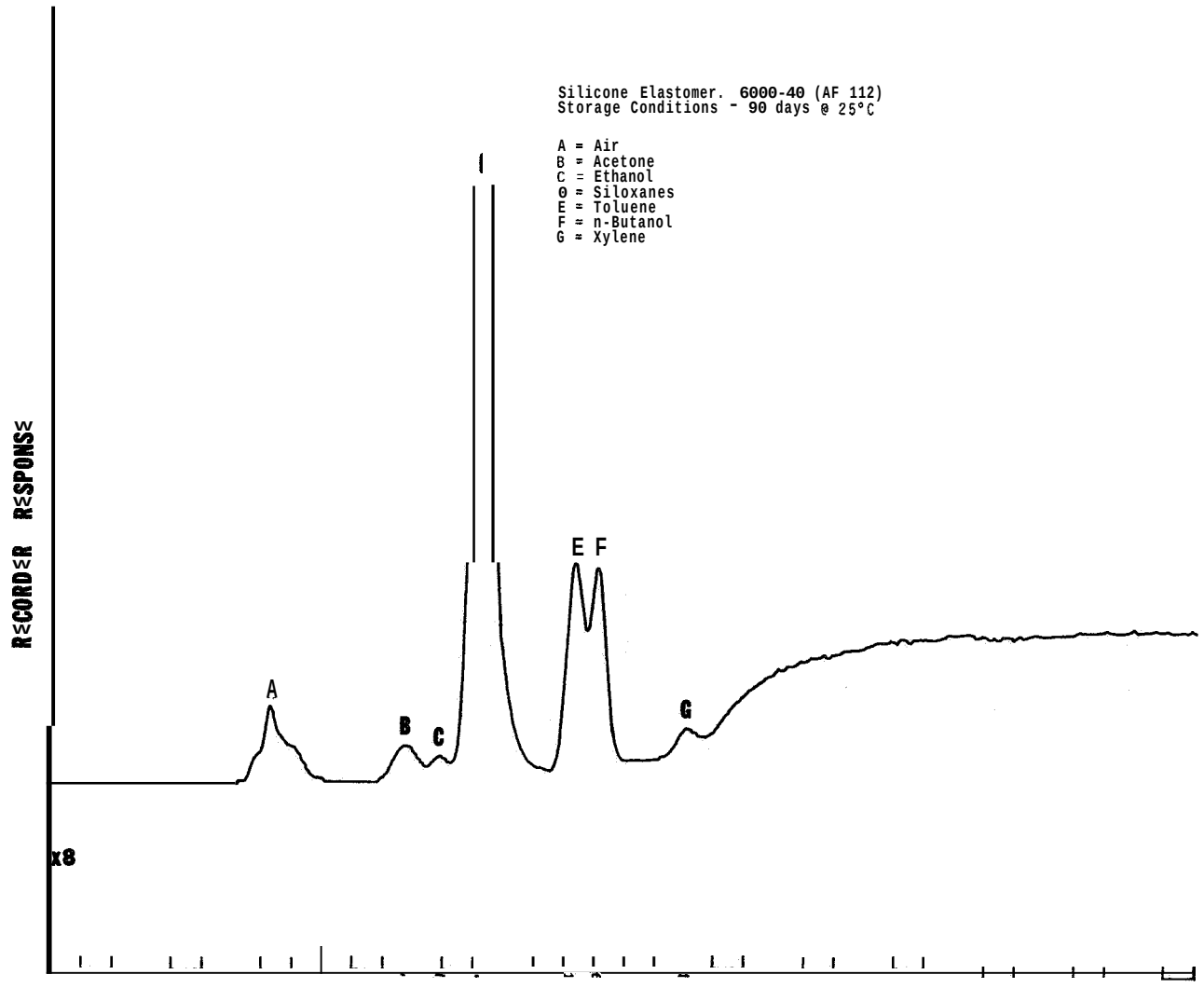

Figure 41. Gas Chromatogram of Gas-Off Products from **Silicone** Elastomer, 6000-40 (AF 112) (90 days @ 25°C).

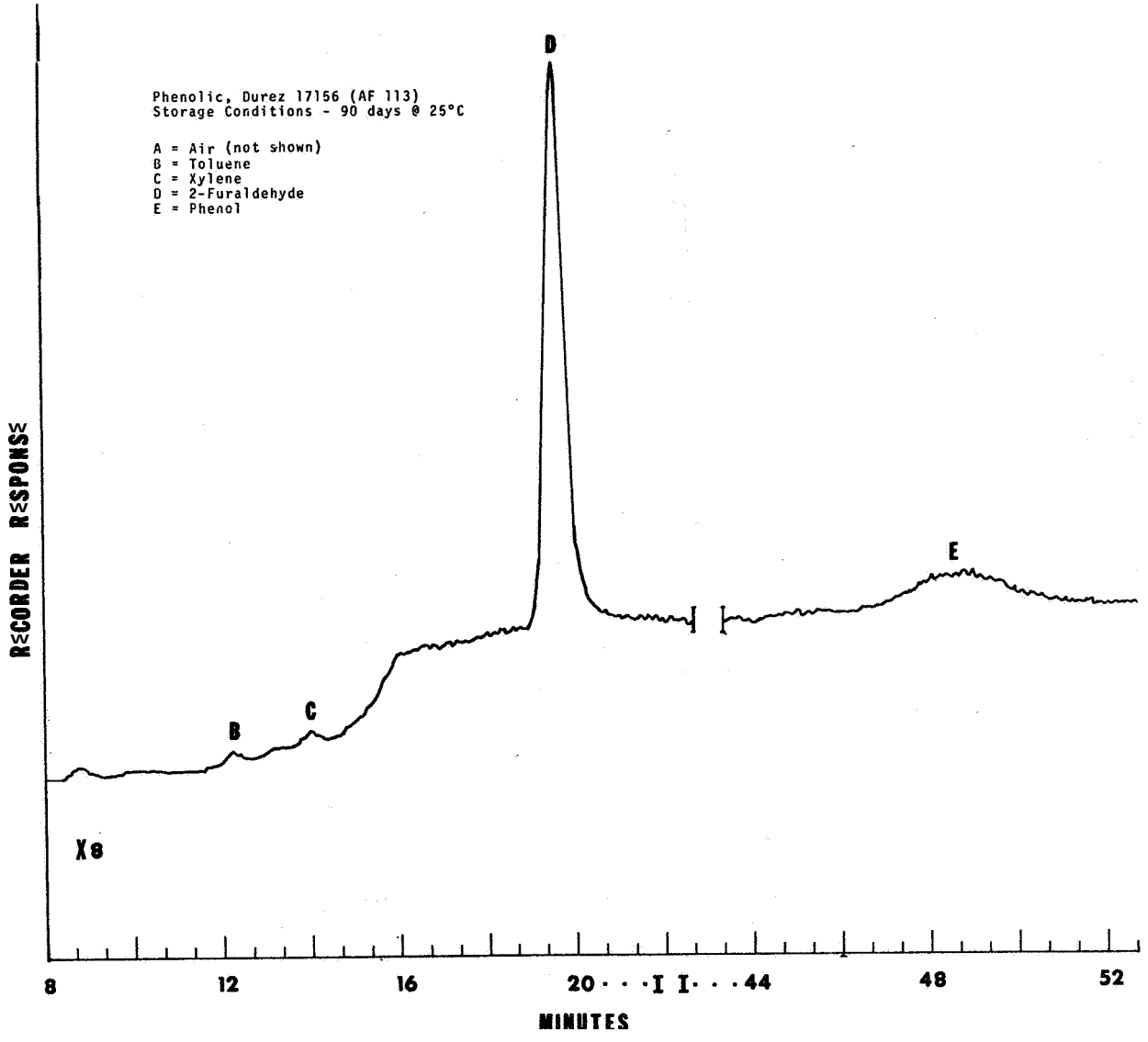

Figure 42. Gas Chromatogram of Gas-Off Products from Phenolic, Durez 17156 (AF 113) (90 days @ 25°C).

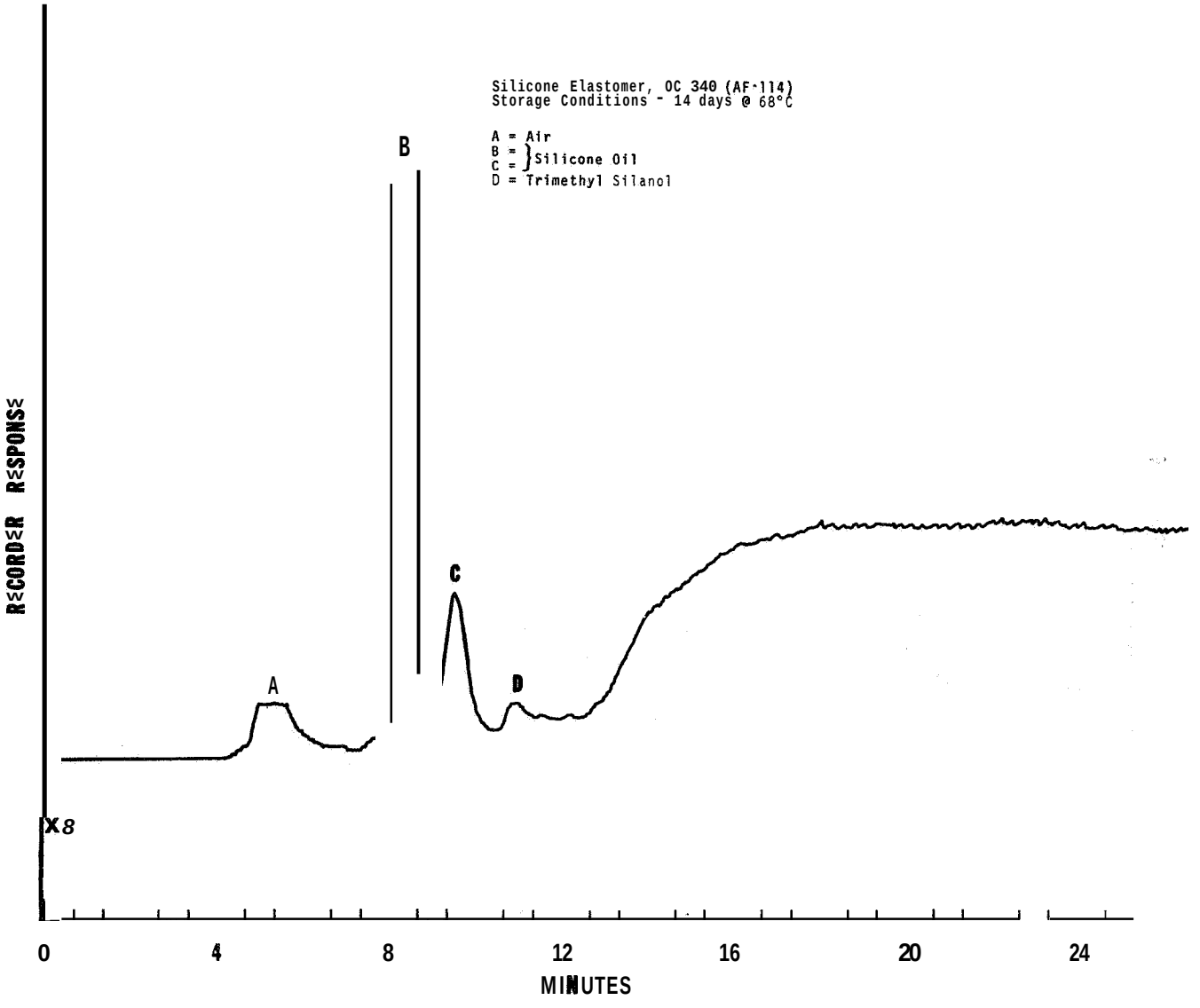

Figure 43. Gas Chromatogram of Gas-Off **Products** from Silicone Elastomer, DC 340 (AF 114) (14 days @ 68°C).

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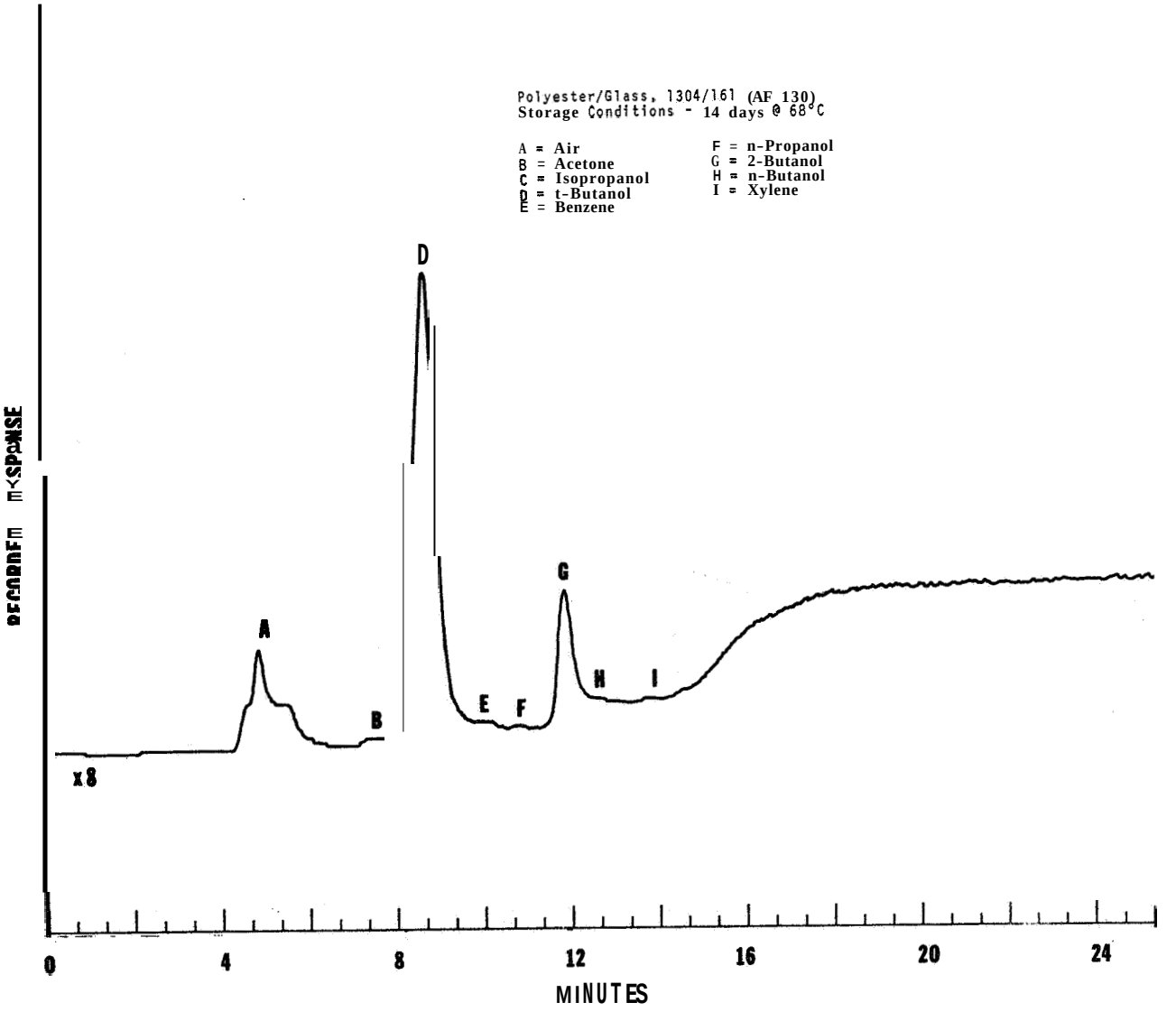

Figure 52. Gas Chromatogram of Gas-Off Products from Polyester/Glass, 1304/161 (AF 130) (14 days @ 68°C).

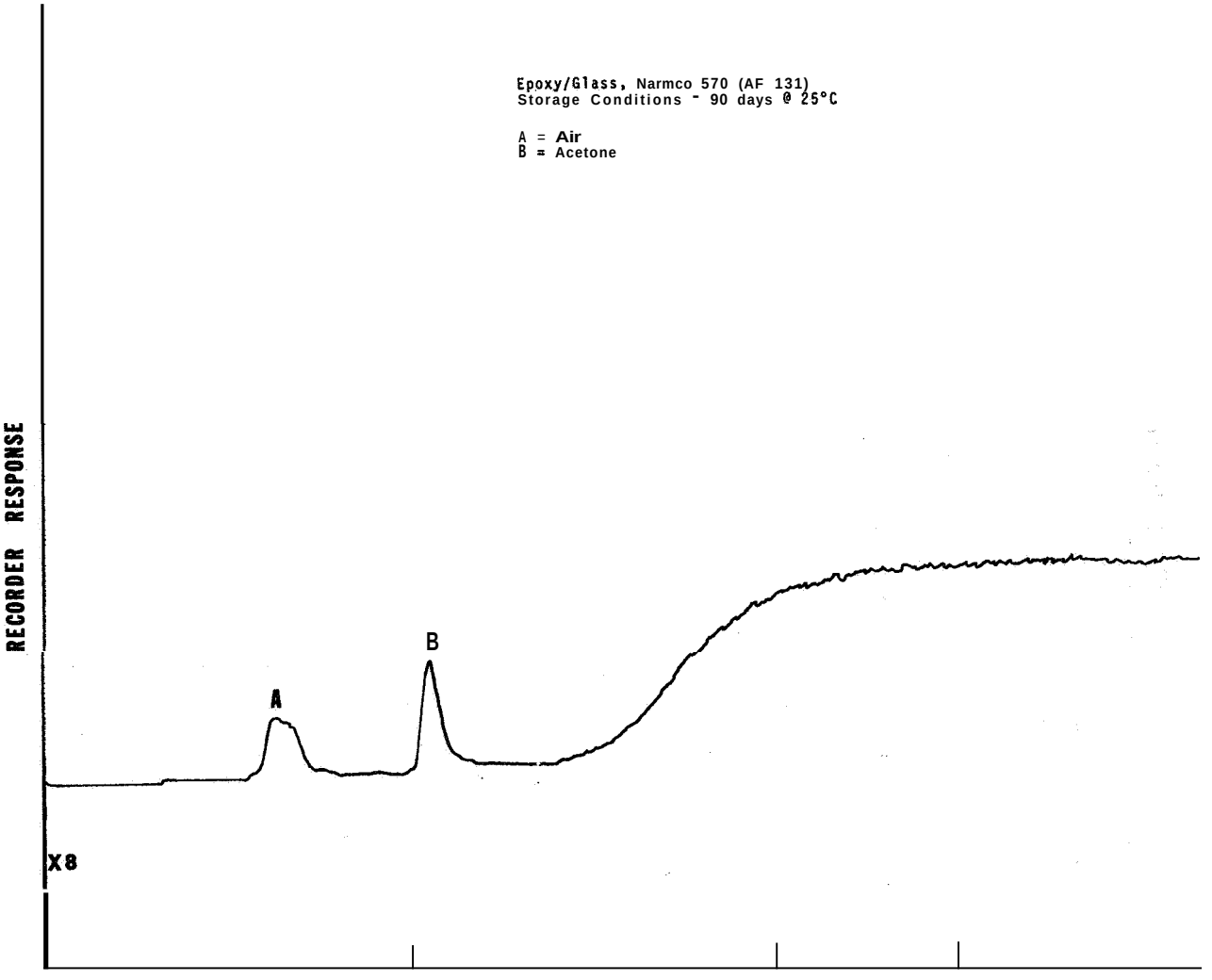

Figure 53. Gas Chromatogram of Gas-Off Products from Epoxy/Glass, Narmco S70 (AF 131) (90 days @ 25°C).

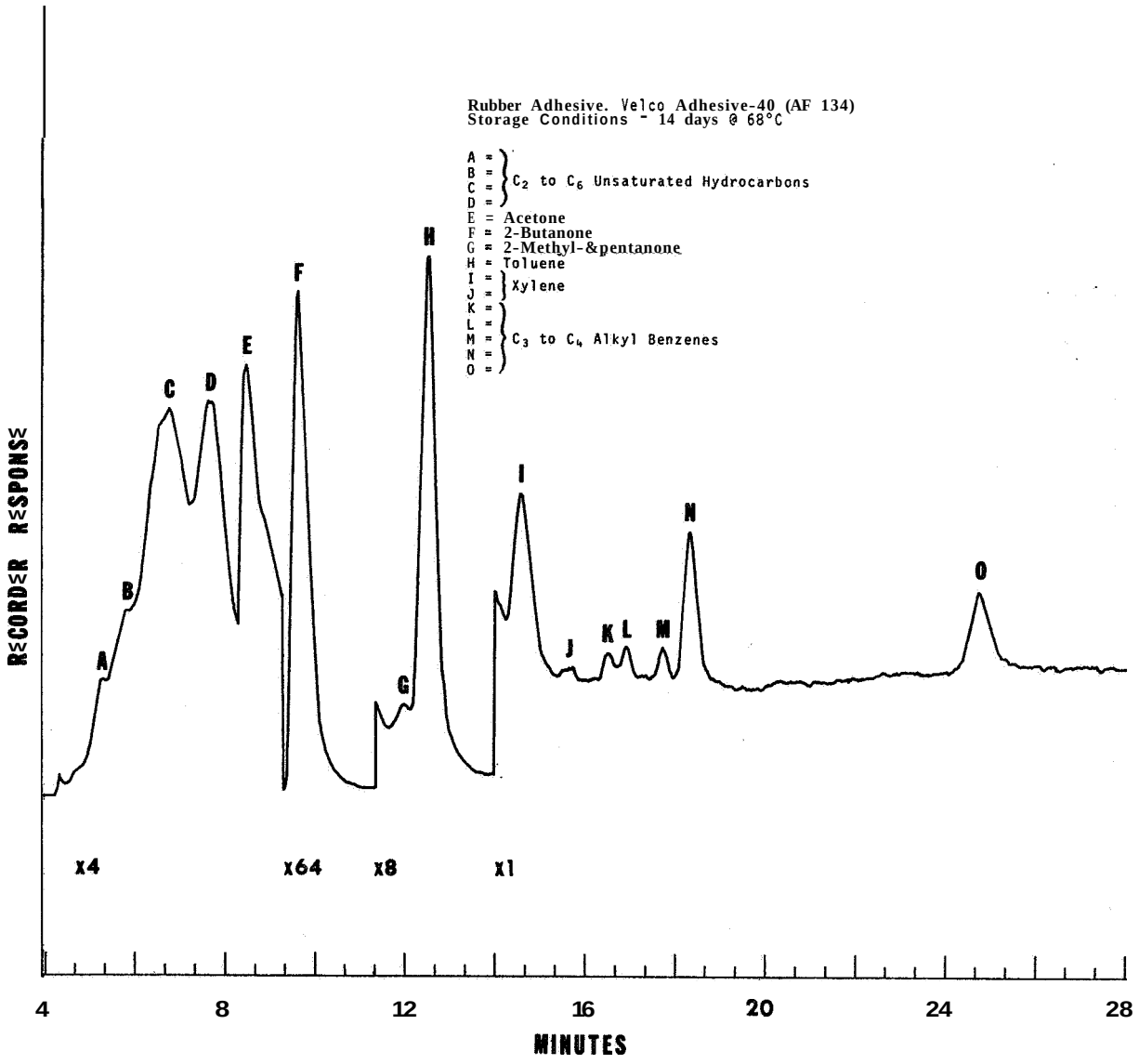

Figure 54. Gas Chromatogram of Gas-Off Products from Rubber Adhesive, Velco Adhesive-40 (AF 134) (14 days @ 68°C).

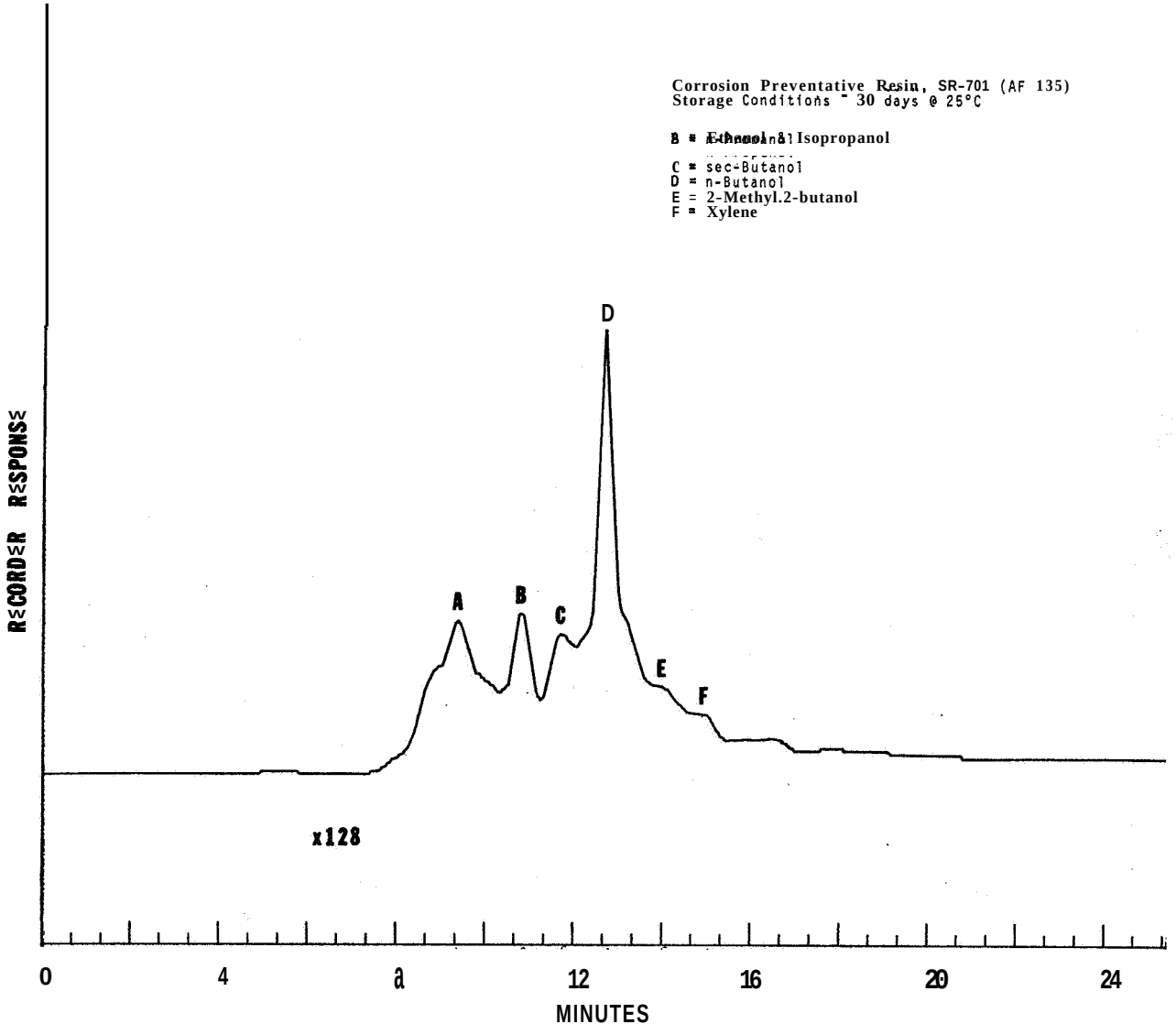

Figure 55. Gas Chromatogram of Gas-Off Products from Corrosion Preventative Resin, SR-701 (AF 135) (30 days @ 25°C).

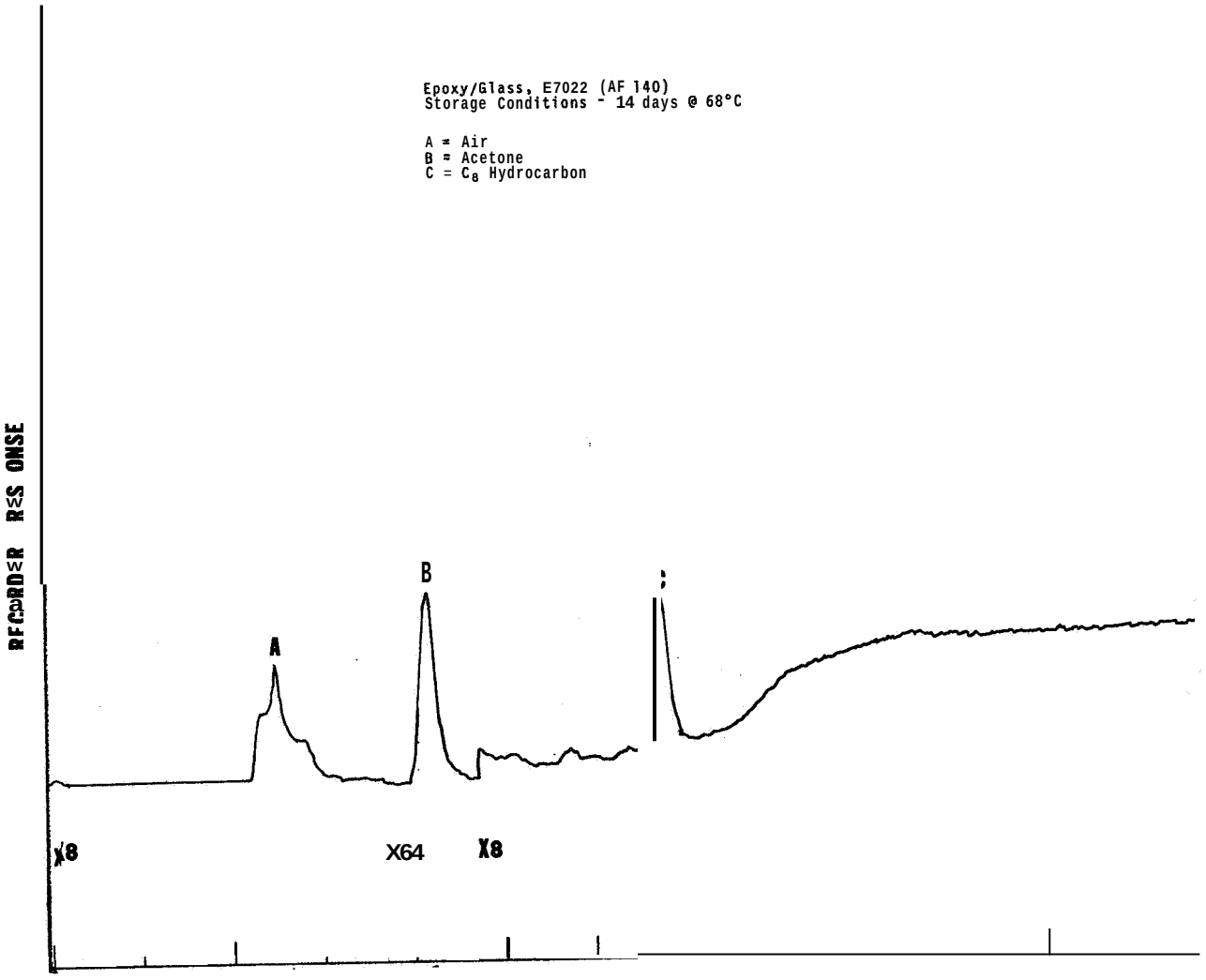

Figure 56. Gas Chromatogram of Gas-Off Products from Epoxy/Glass, E7022 (AF 140) (14 days @ 68°C).

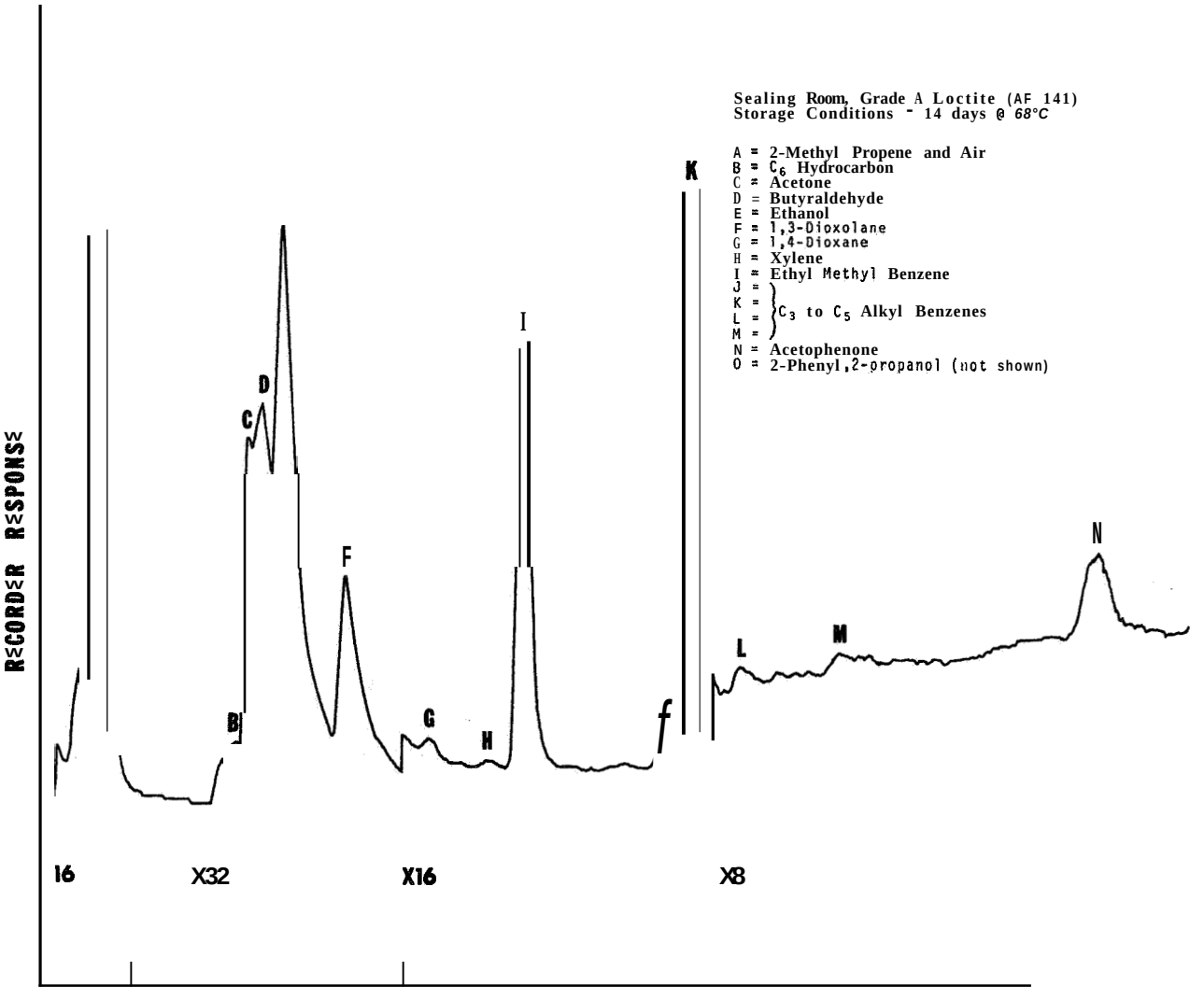

Figure 57. Gas Chromatogram of Gas-Off Products from Sealing Room, Grade A Loctite (AF 141) (14 days @ 68°C).

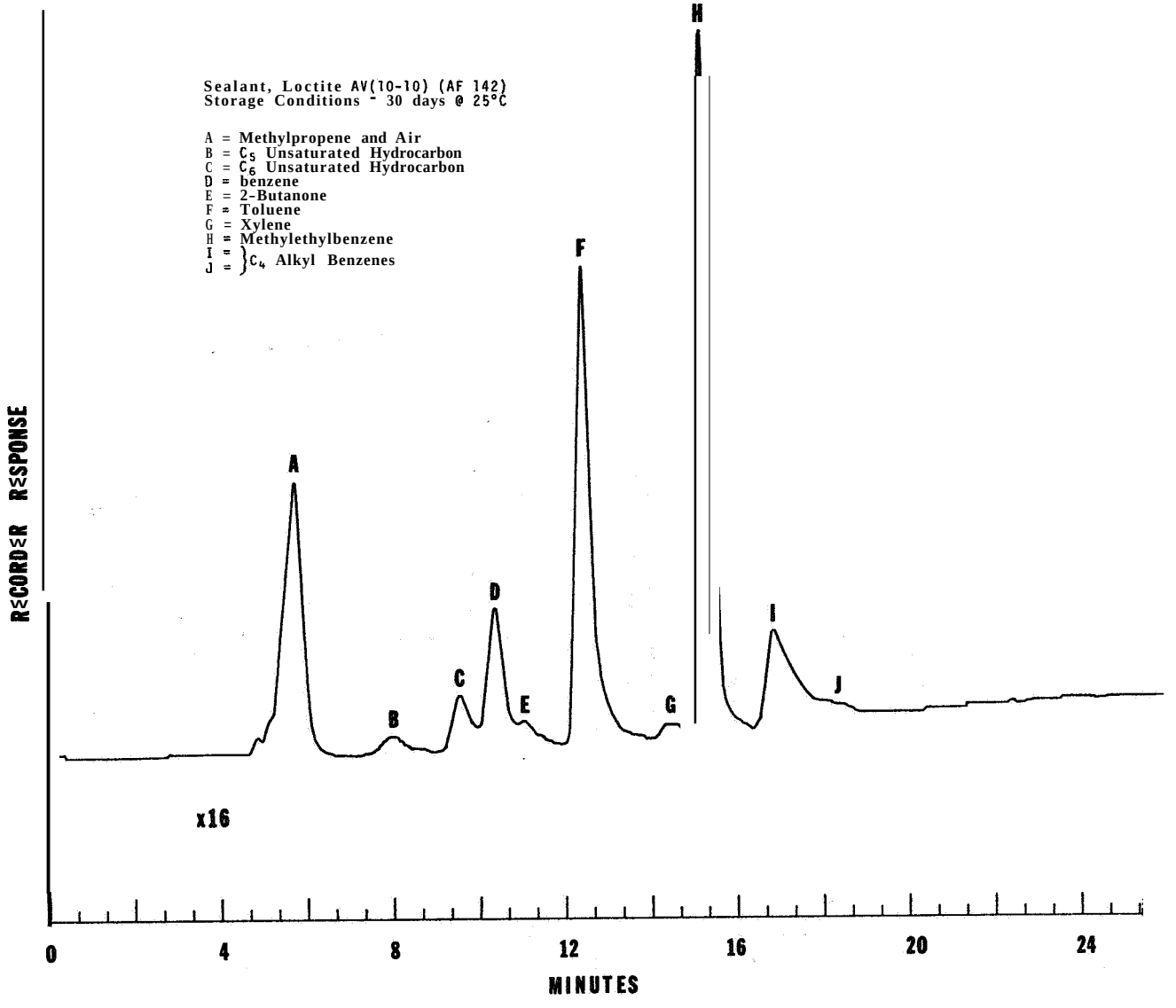

Figure 58. Gas Chromatogram of Gas-Off Products from Sealant, Loctite AV(10-10) (AF 142) (30 days @ 25°C).

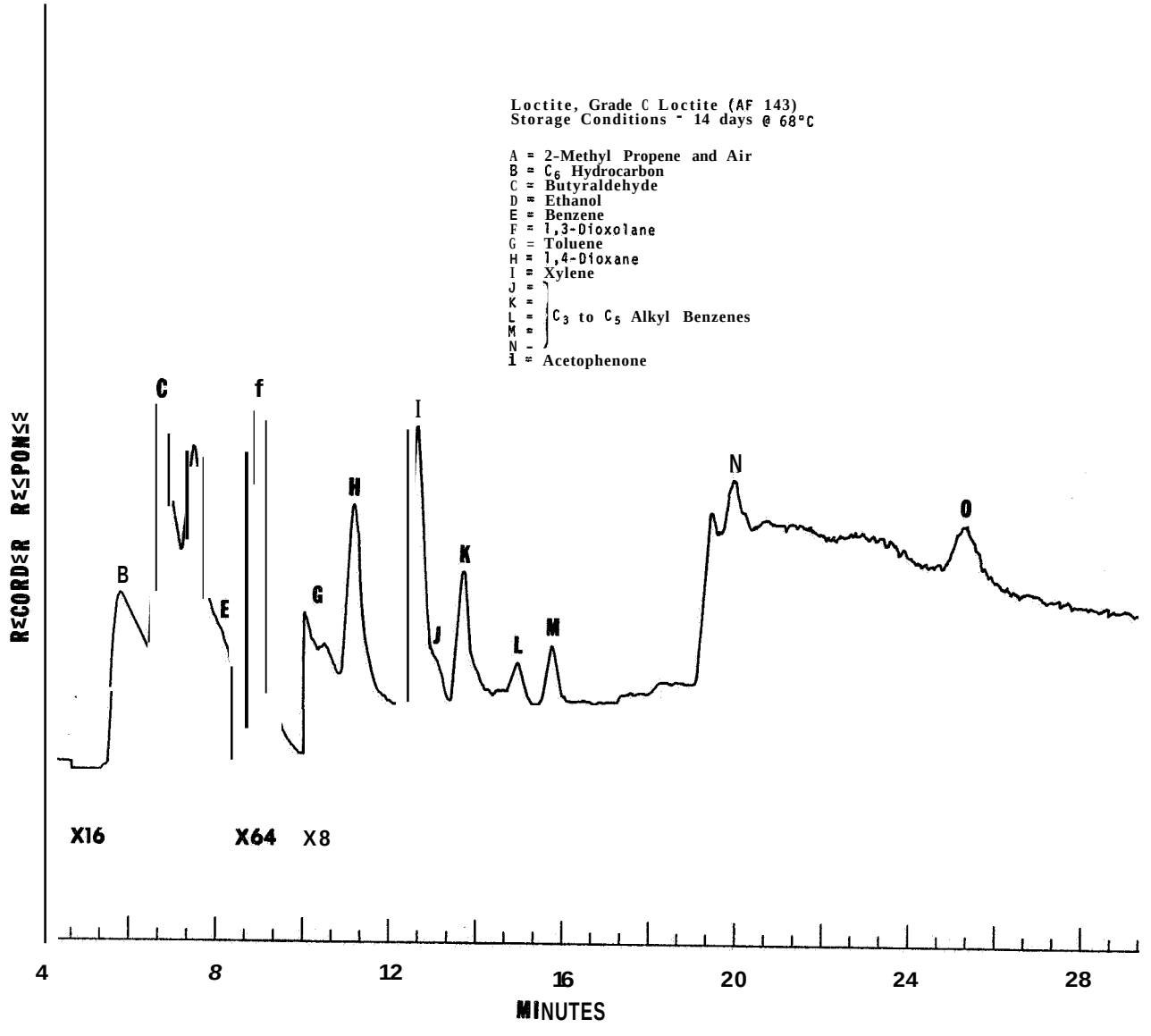

Figure 59. Gas Chromatogram of Gas-Off Products from Loctite, Grade C Loctite (AF 143) (14 days @ 68°C).

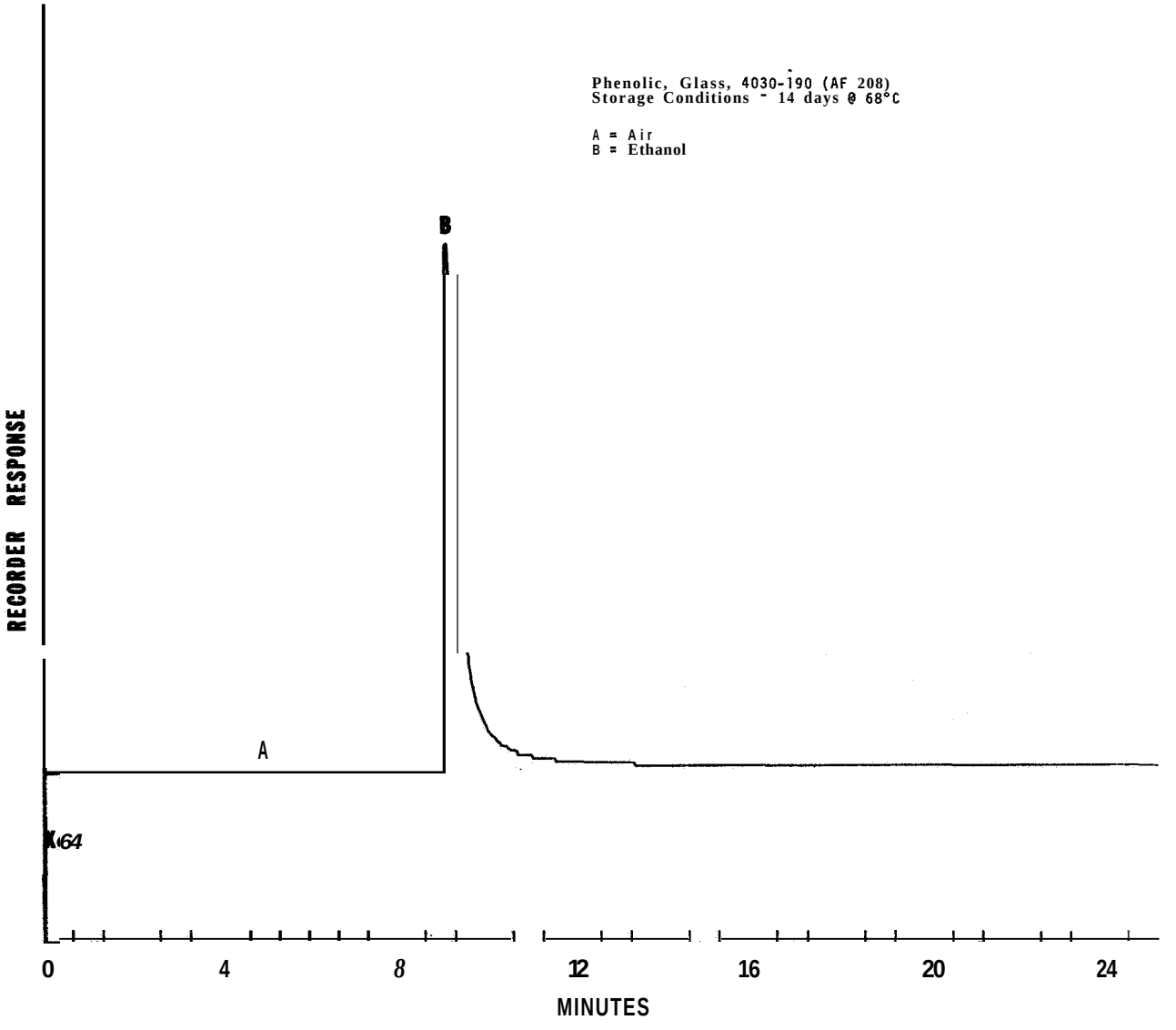

Figure 60. Gas Chromatogram of Gas-Off Products from Phenolic, Glass, 4030-190 (AF 208) (14 days @ 68°C).

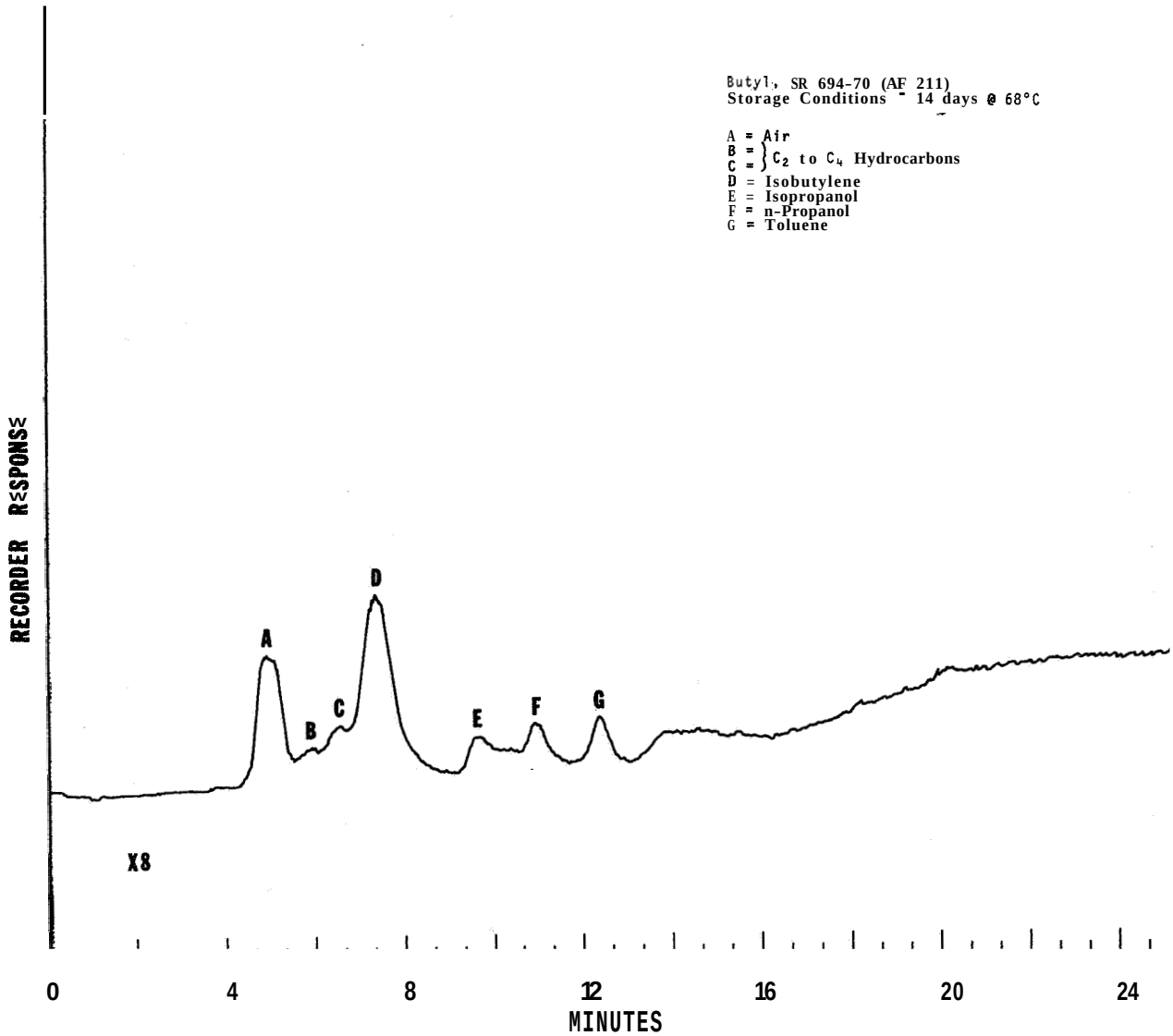

Figure 61. Gas Chromatogram of Gas-Off Products from Butyl, SR 694-70 (AF 211) (14 days @ 68°C).

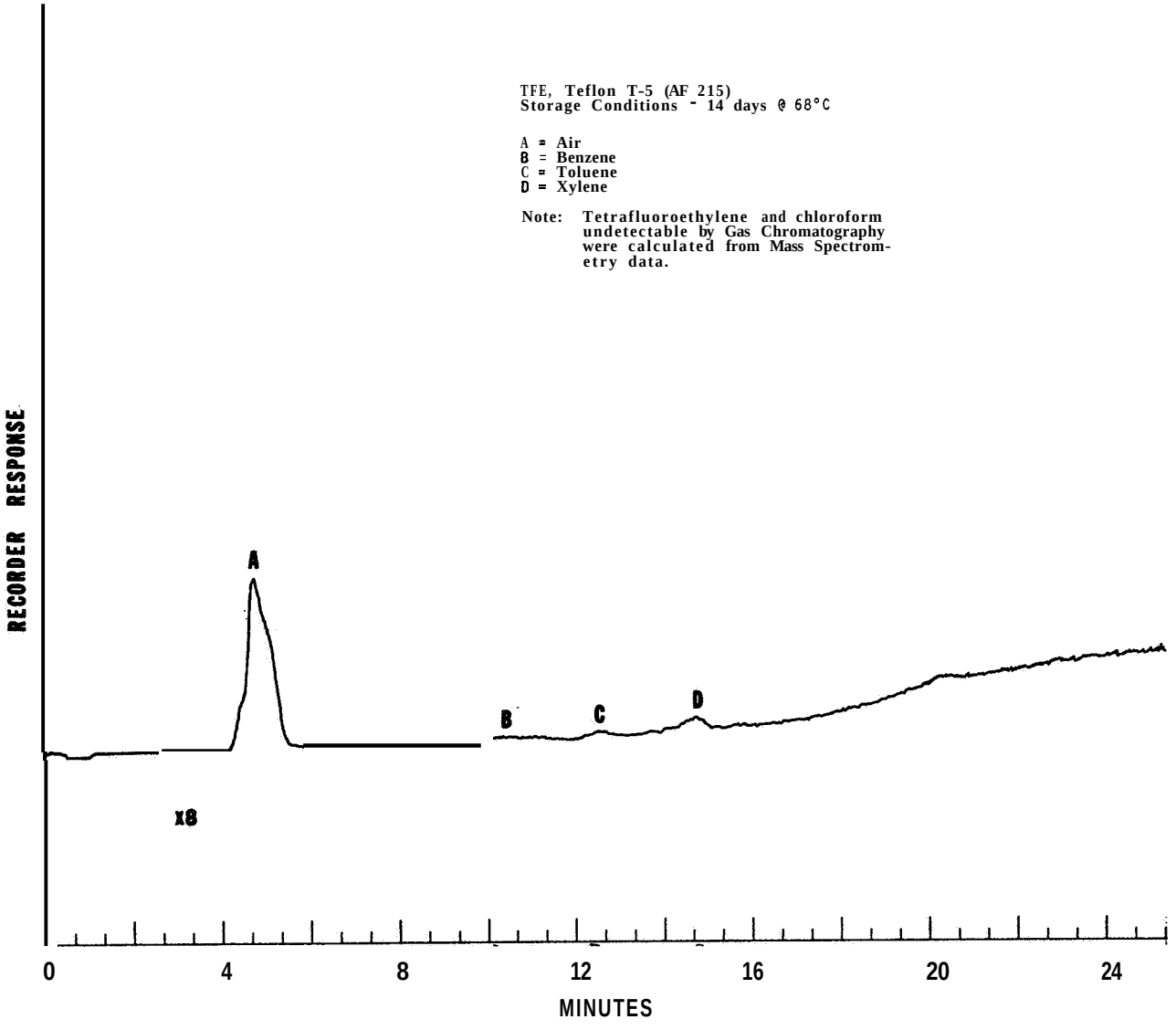

Figure 62, Gas Chromatogram of Gas–Off Products from TFE, **Teflon** T–5 (AF 215) (14 days @ 68°C).

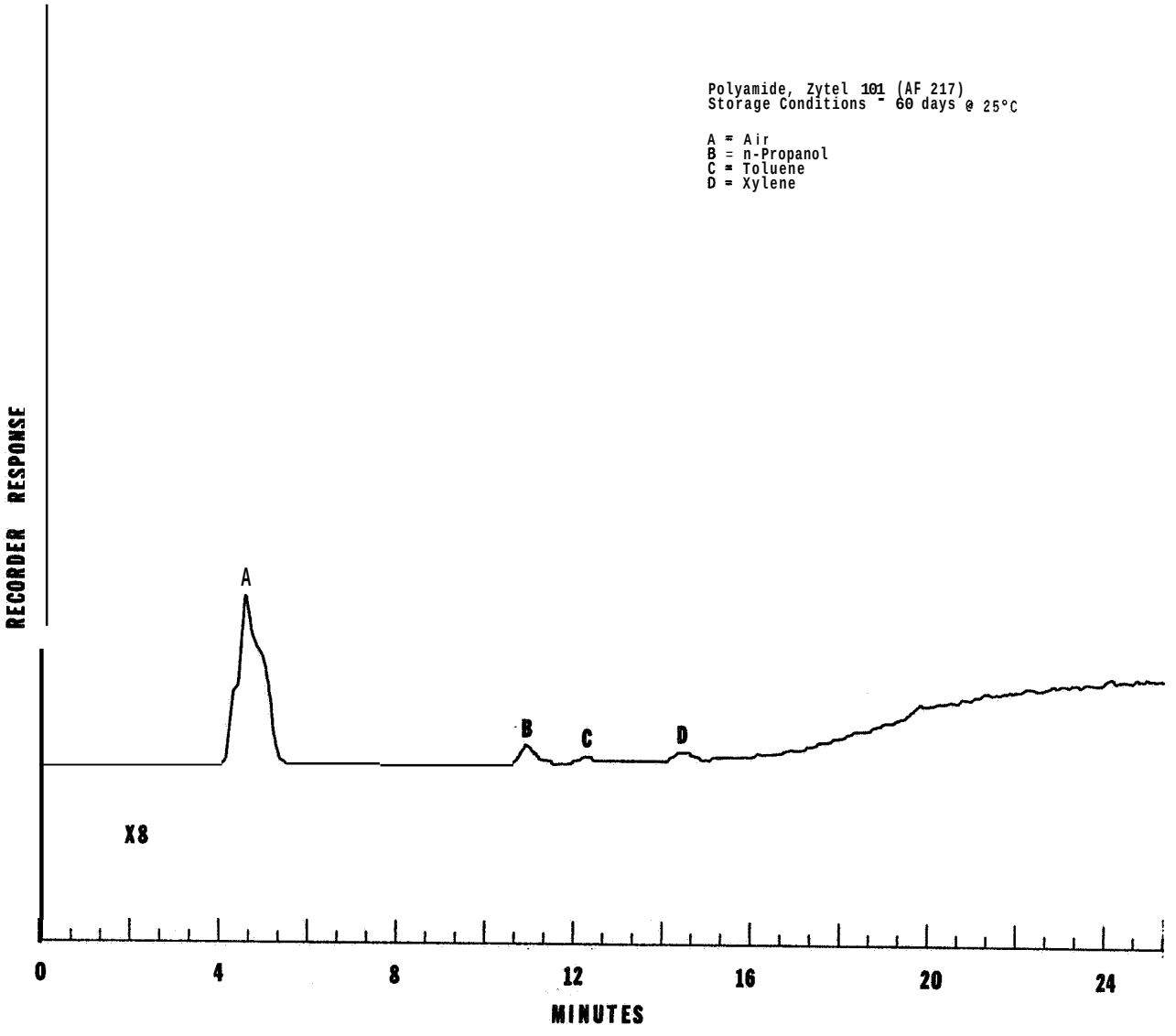

Figure 63. Gas Chromatogram of Gas-Off Products from Polyamide, Zytel 101 (AF 217) (60 days @ 25°C).

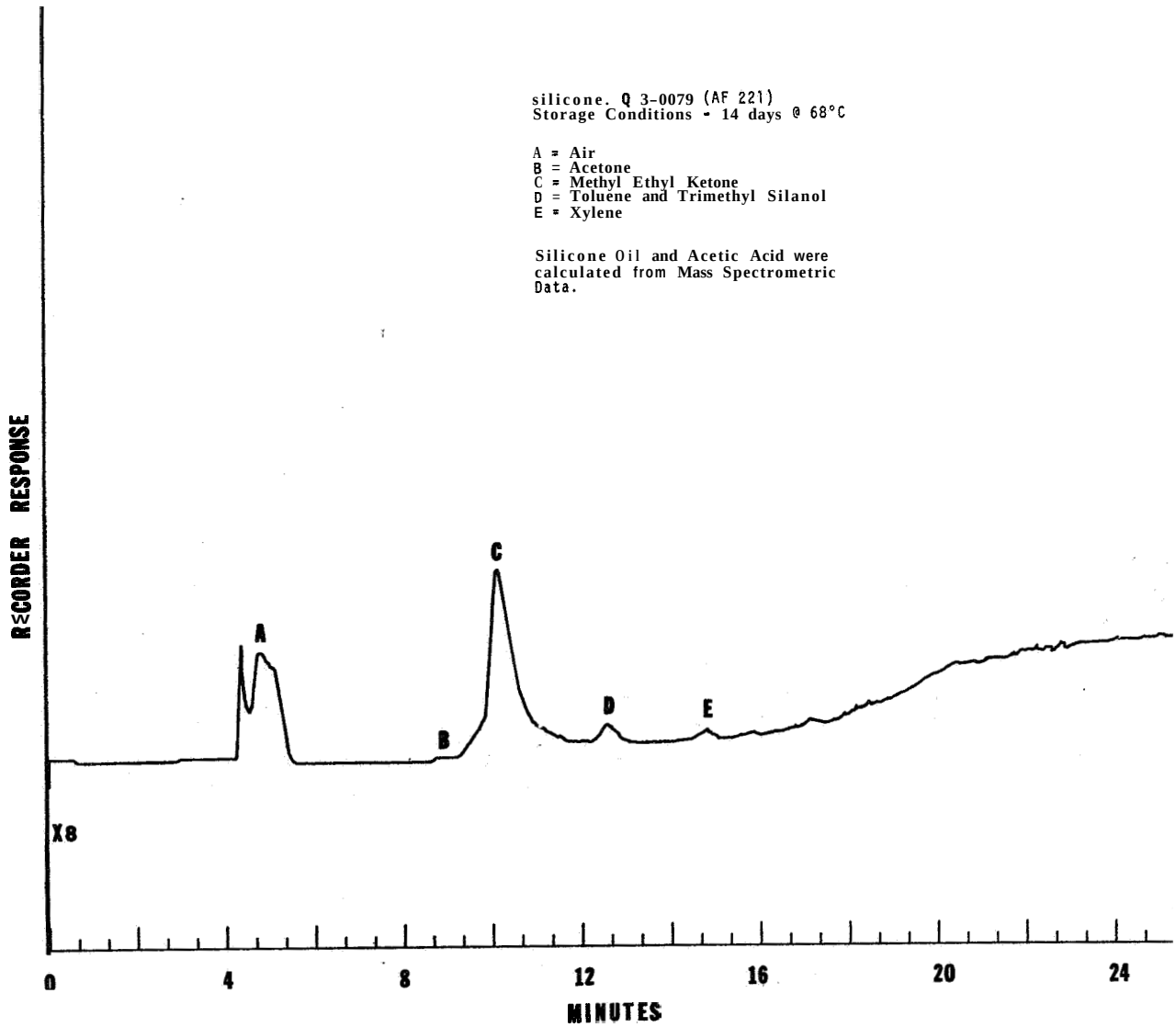

Figure 64. Gas Chromatogram of Gas-Off Products from Silicone, Q 3-0079 (AF 221) (14 days @ 68°C).

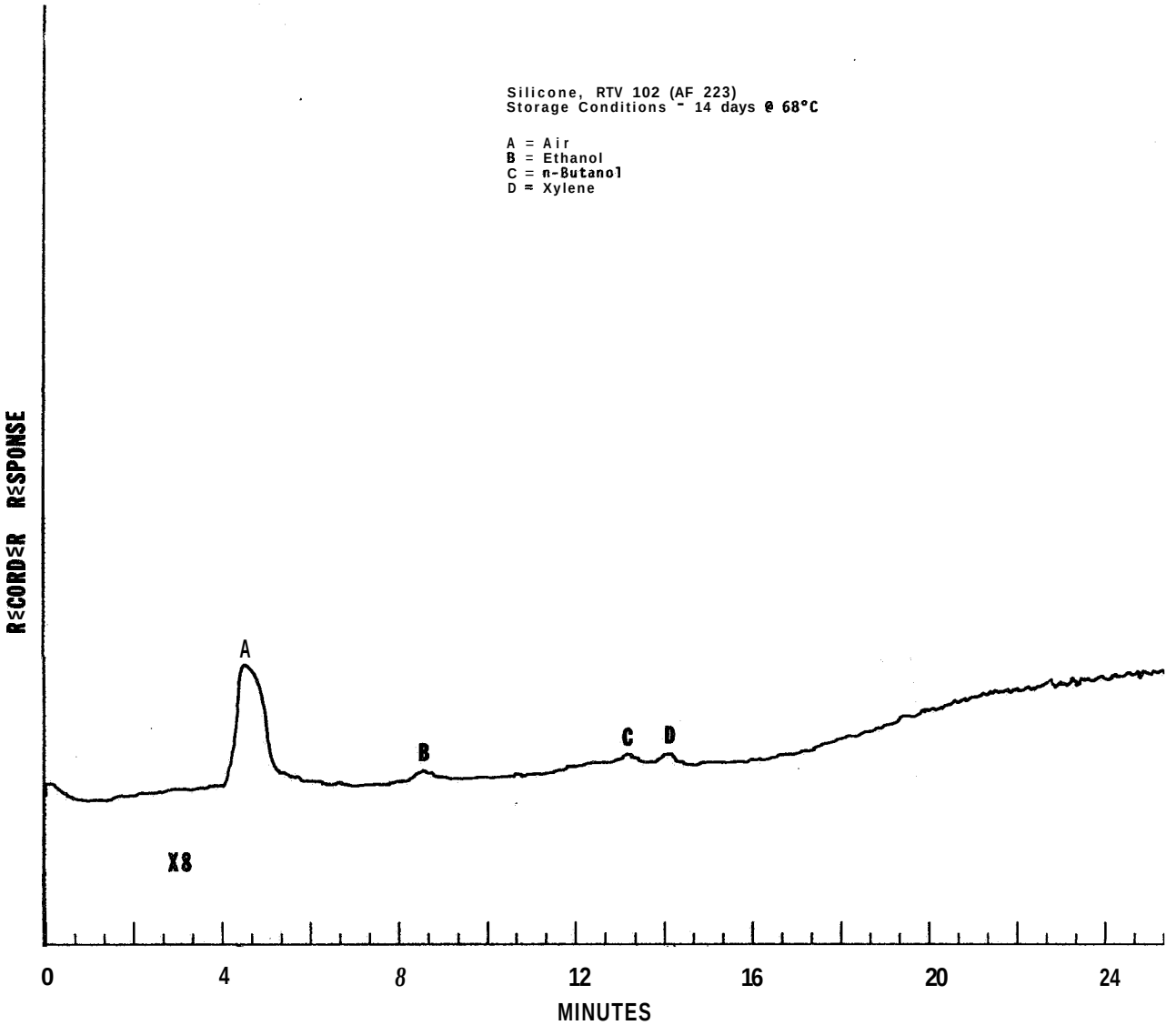

Figure 65. Gas Chromatogram of Gas-Off Products from Silicone, RTV **102** (AF 223) (14 days @ 68°C).

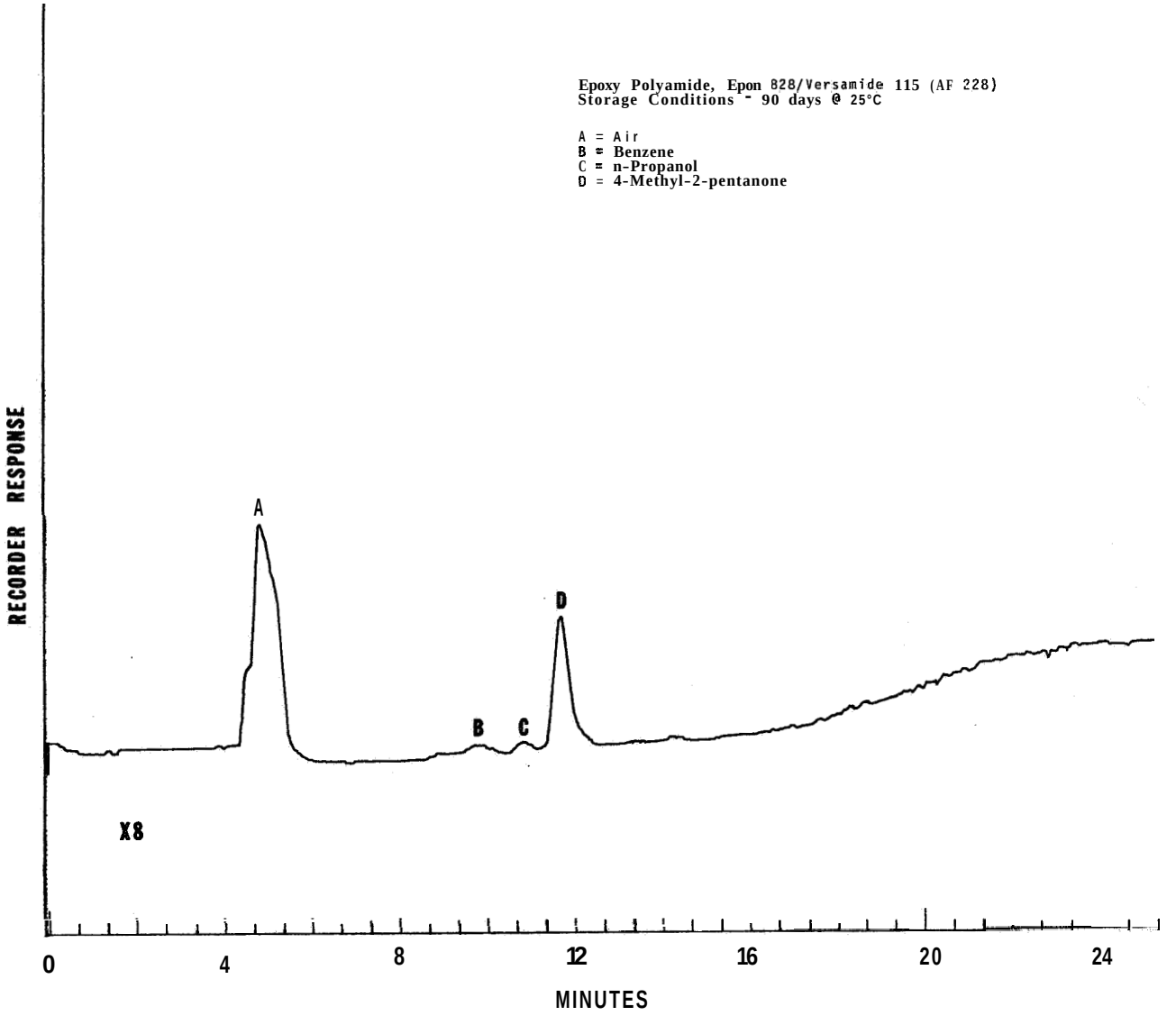

Figure 66. Gas Chromatogram of Gas-Off Products from Epoxy Polyamide, Epon 828/Versamide 115 (AF 228) (90 days @ 25°C).

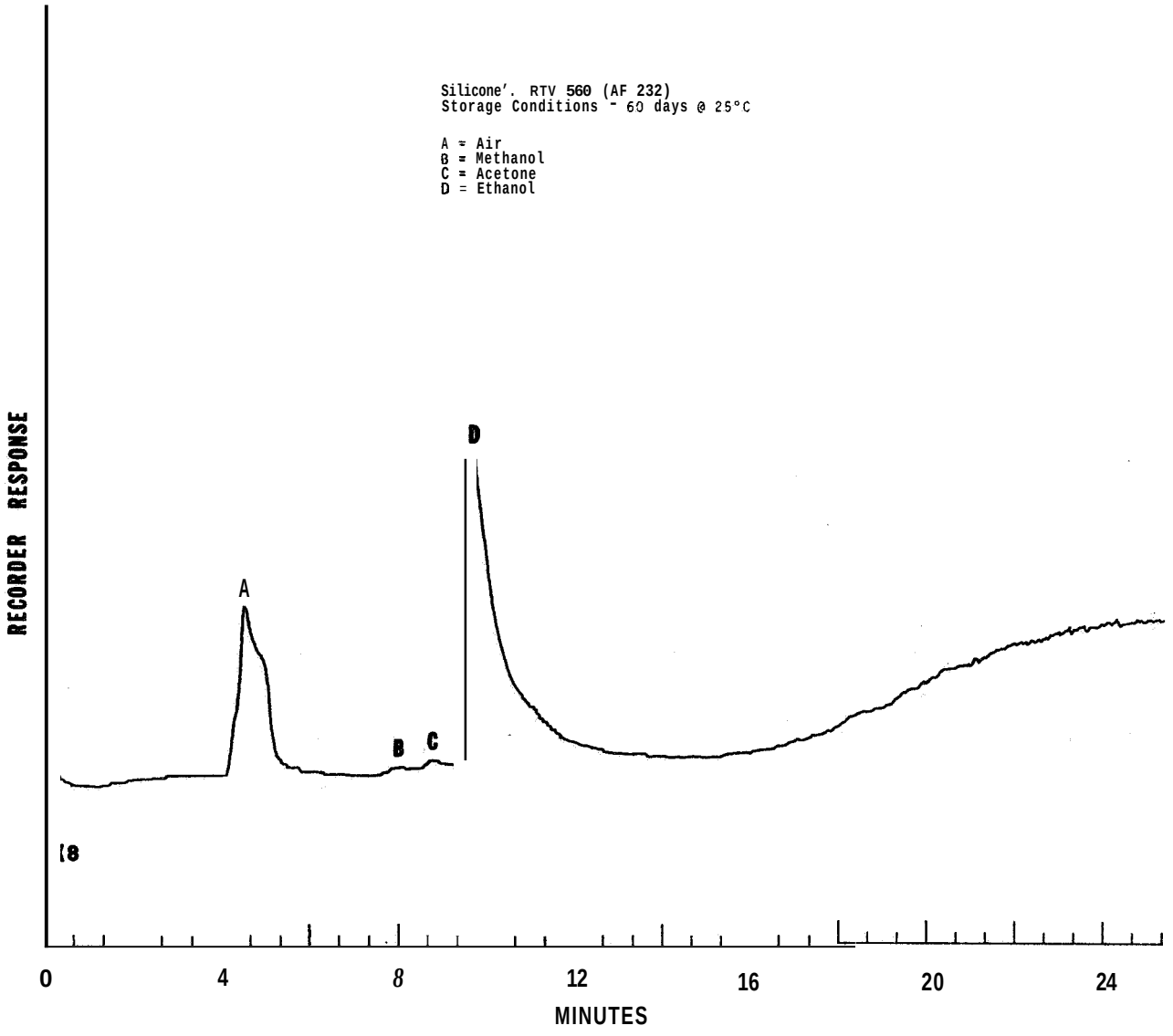

Figure 67. Gas Chromatogram of Gas-Off Products from Silicone, RTV 560 (AF 232) (60 days @ 25°C).

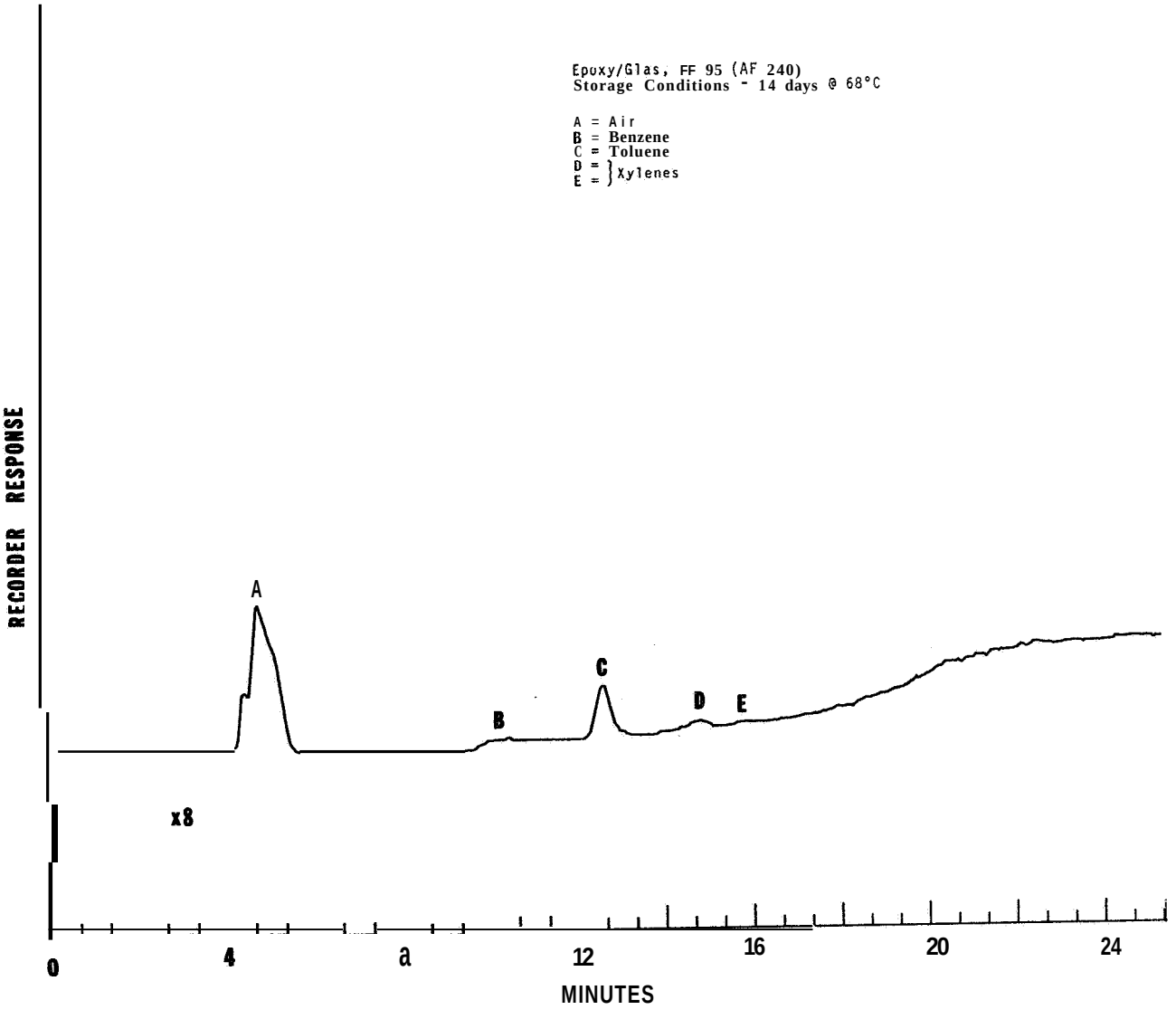

Figure 68. Gas Chromatogram of Gas-Off Products from Epoxy/Glas, FF95 (AF 240) (14 days @ 68°C).

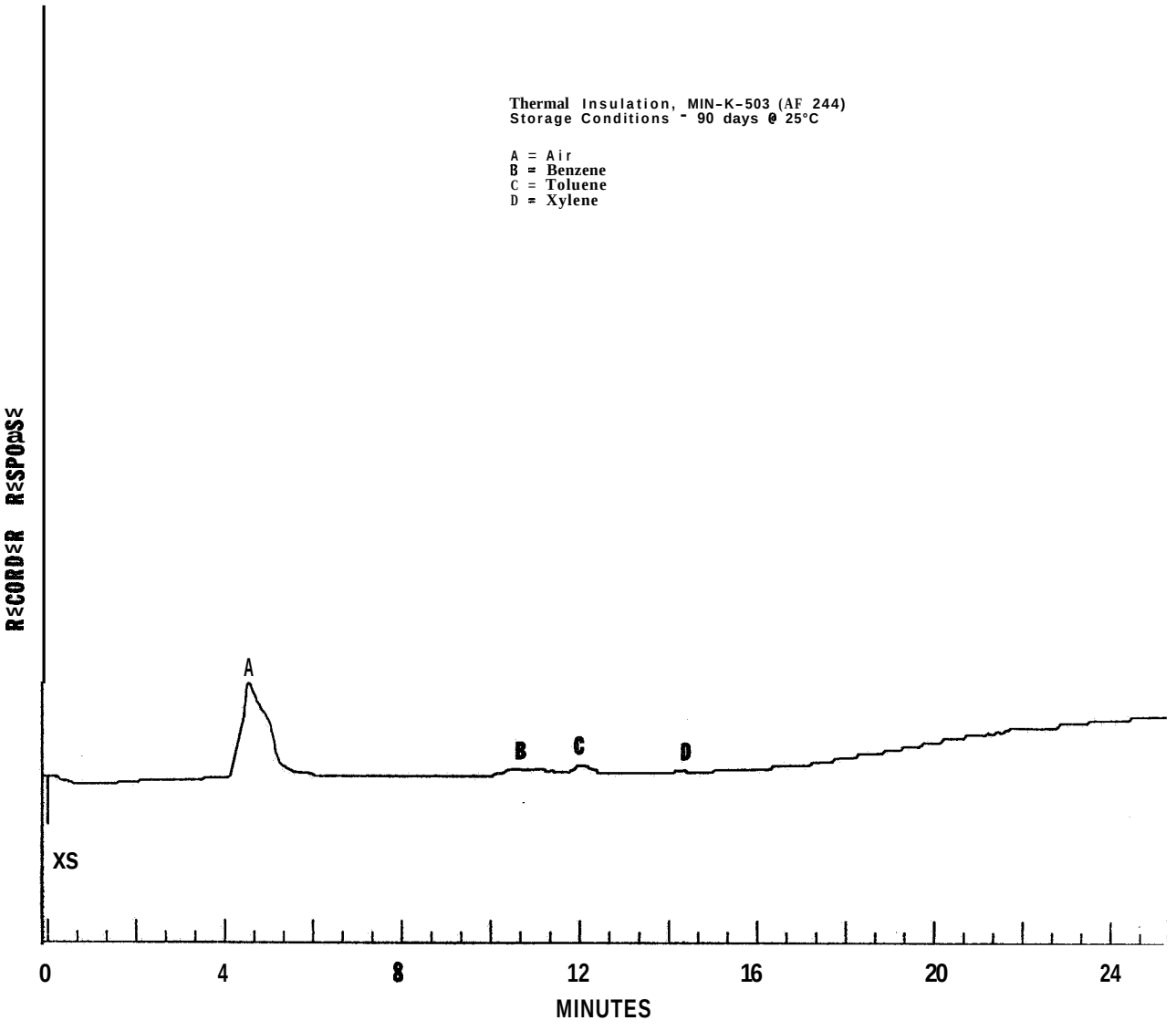

Figure 69. Gas Chromatogram of Gas-Off Products from Thermal Insulation, MIN-K-503 (AF 244) (90 days @ 25°C).

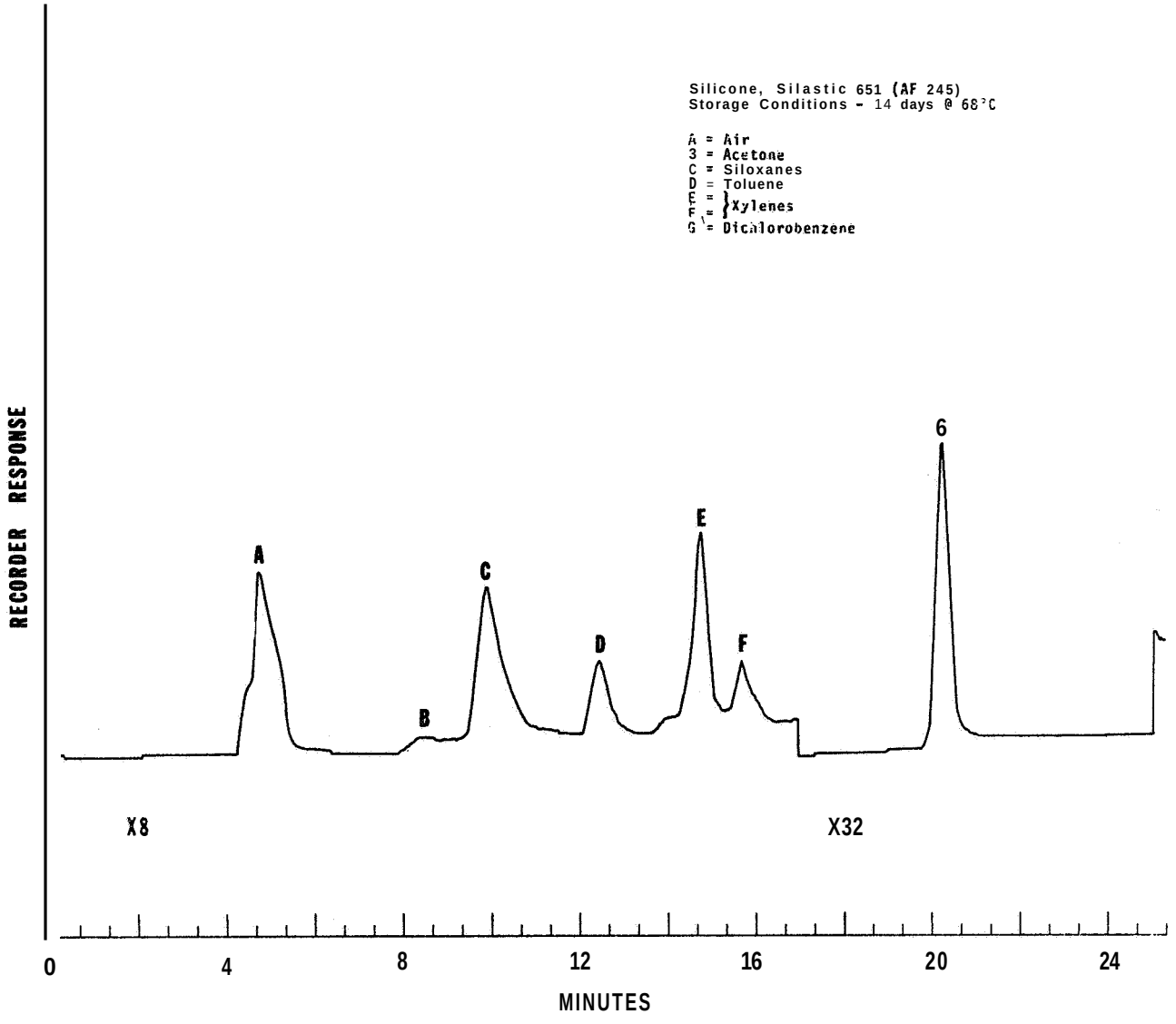

Figure 70. Gas Chromatogram of Gas-Off Products from Silicone, Silastic 651 (AF 245) (14 days @ 68°C).

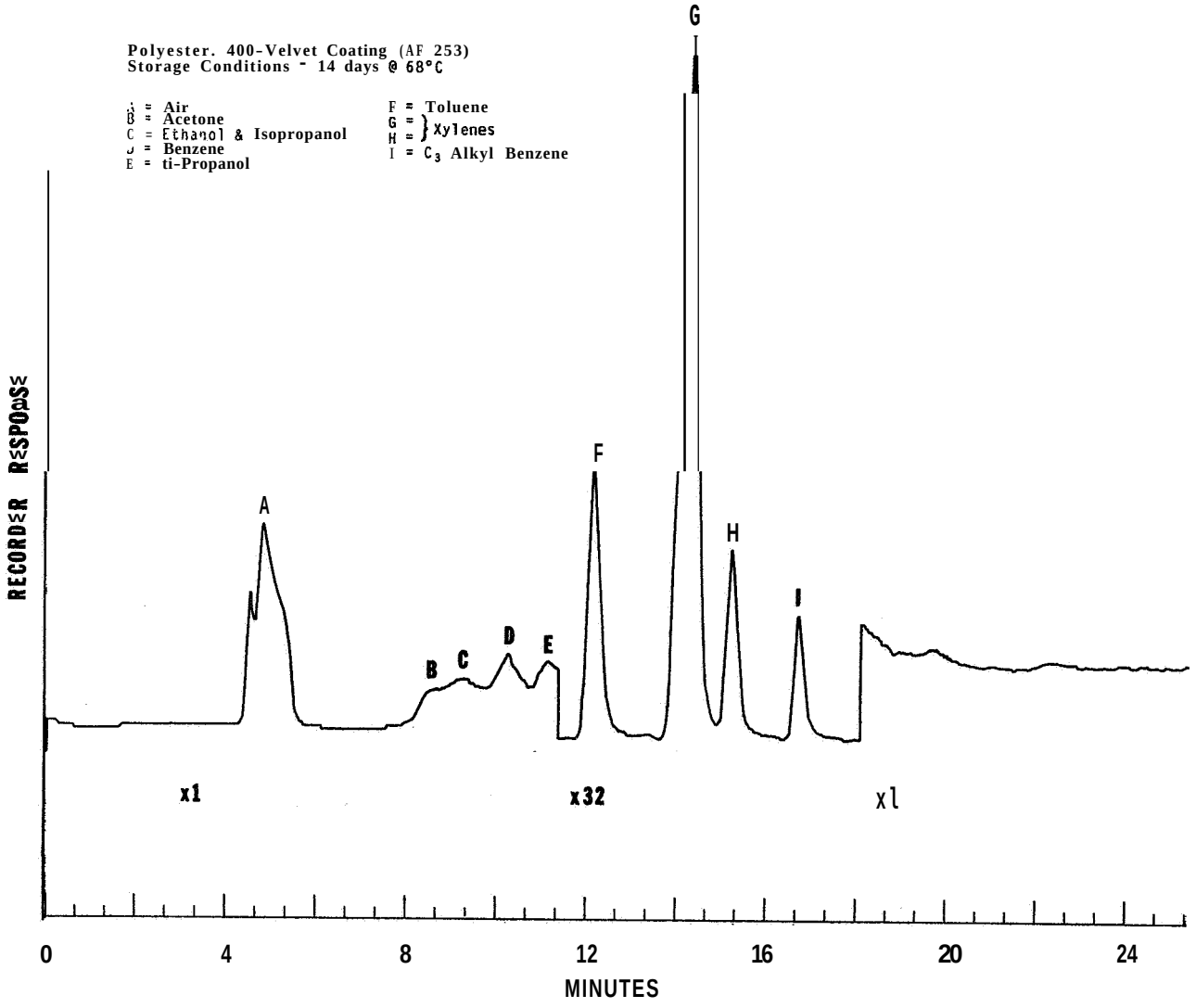

Figure 71. Gas Chromatogram of Gas-Off Products from Polyester, 400-Velvet Coating (AF 258) (14 days @ 68°C).

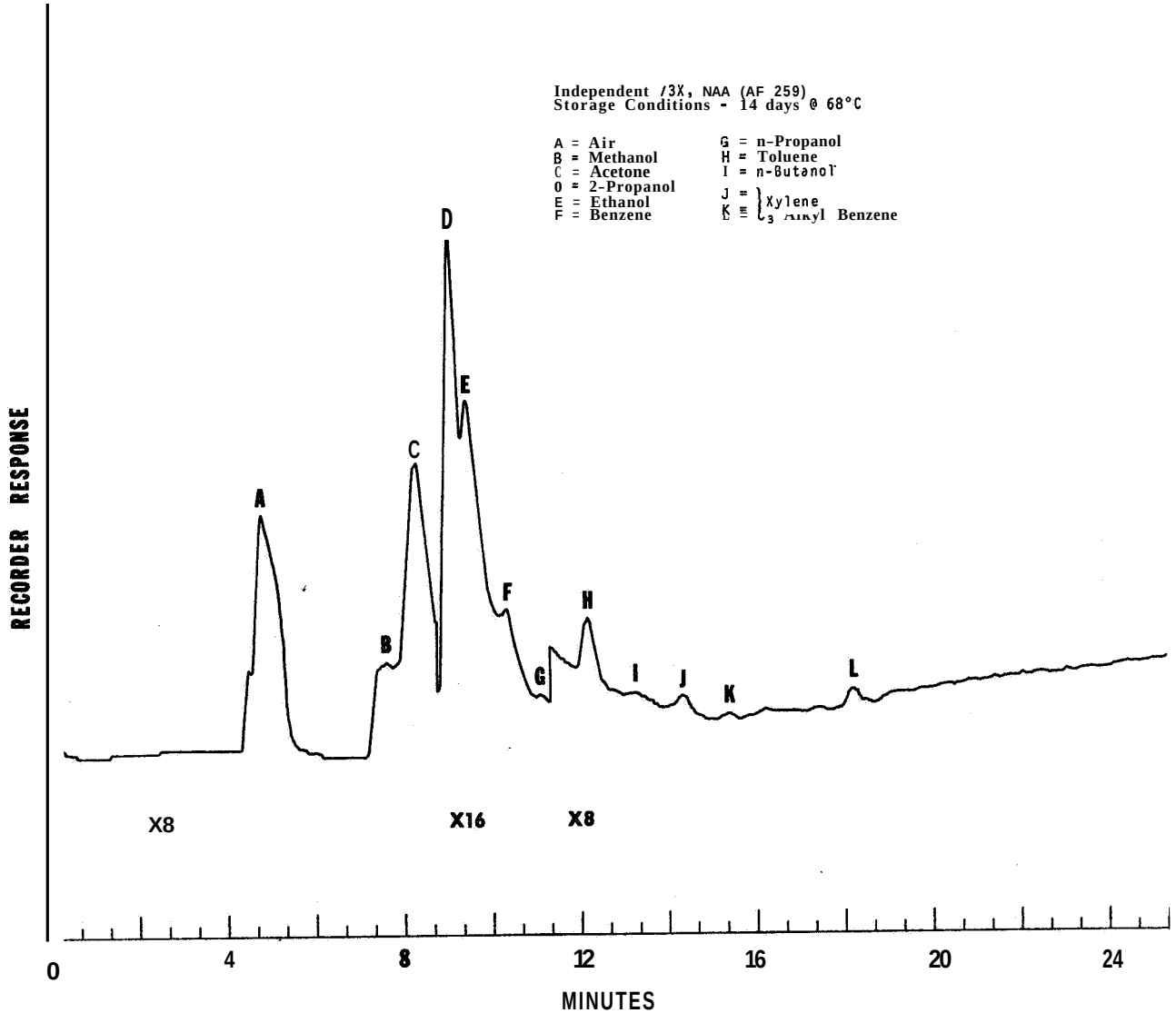

Figure 72. Gas Chromatogram of Gas-Off Products from Independent 73X, NAA (AF 259) (14 days @ 68°C).

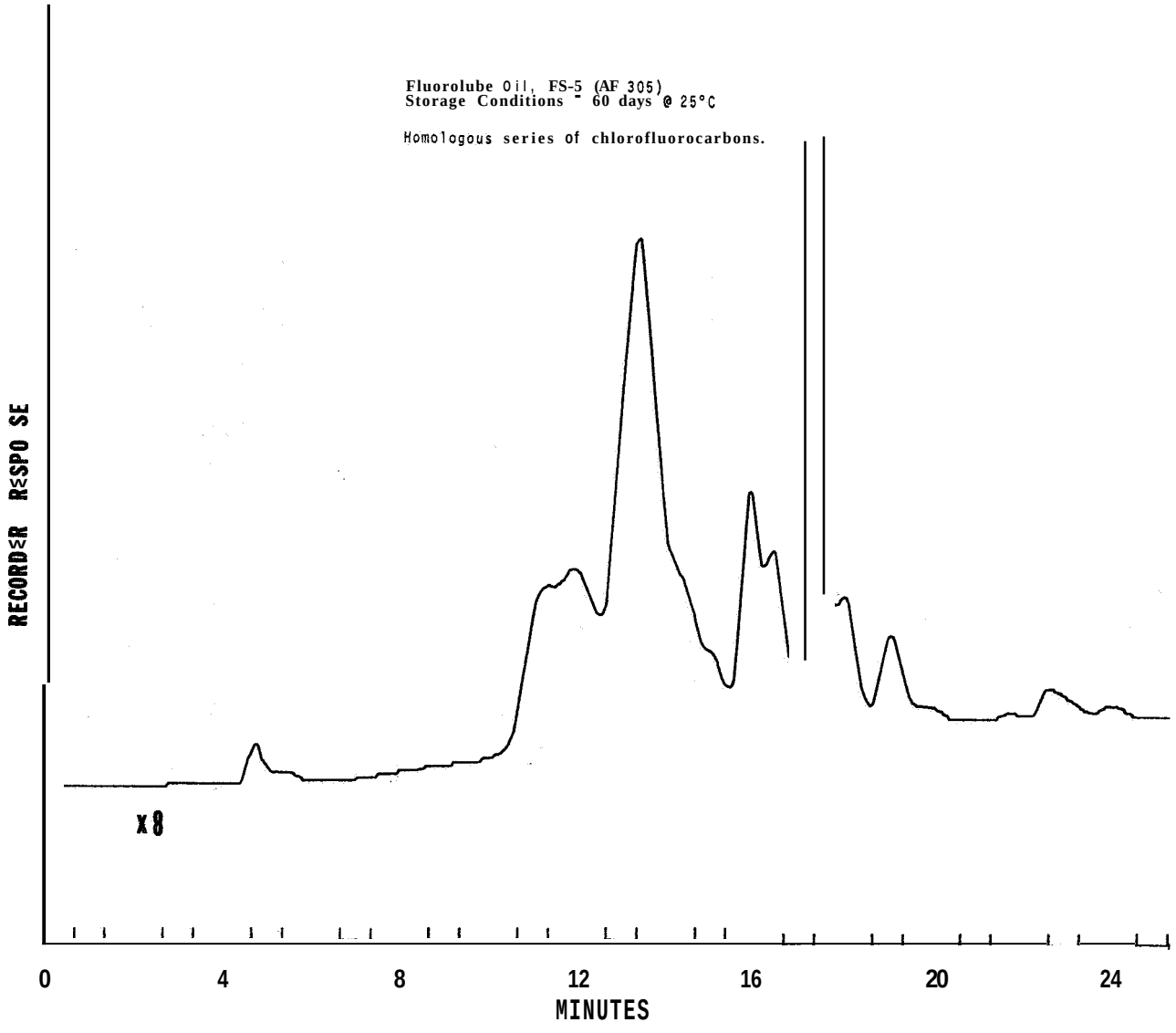

Figure 73. Gas Chromatogram of Gas-Off Products from Fluorolube Oil, FS-5 (AF 305) (60 days @ 25°C).

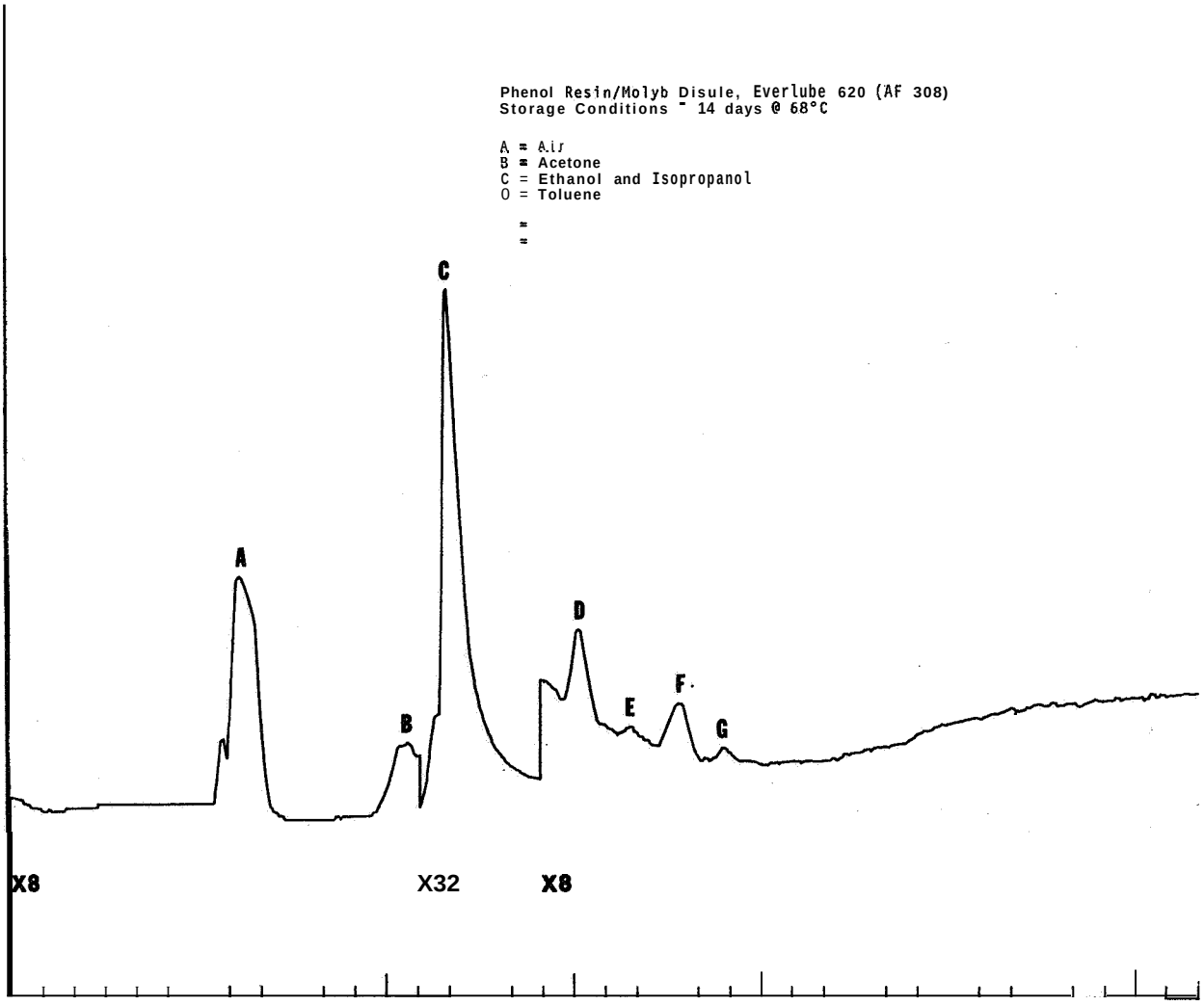

Figure 74. Gas Chromatogram of Gas-Off Products from Phenol Resin/Molyb Disule, Everlube 620 (AF 308) (14 days @ 68°C).

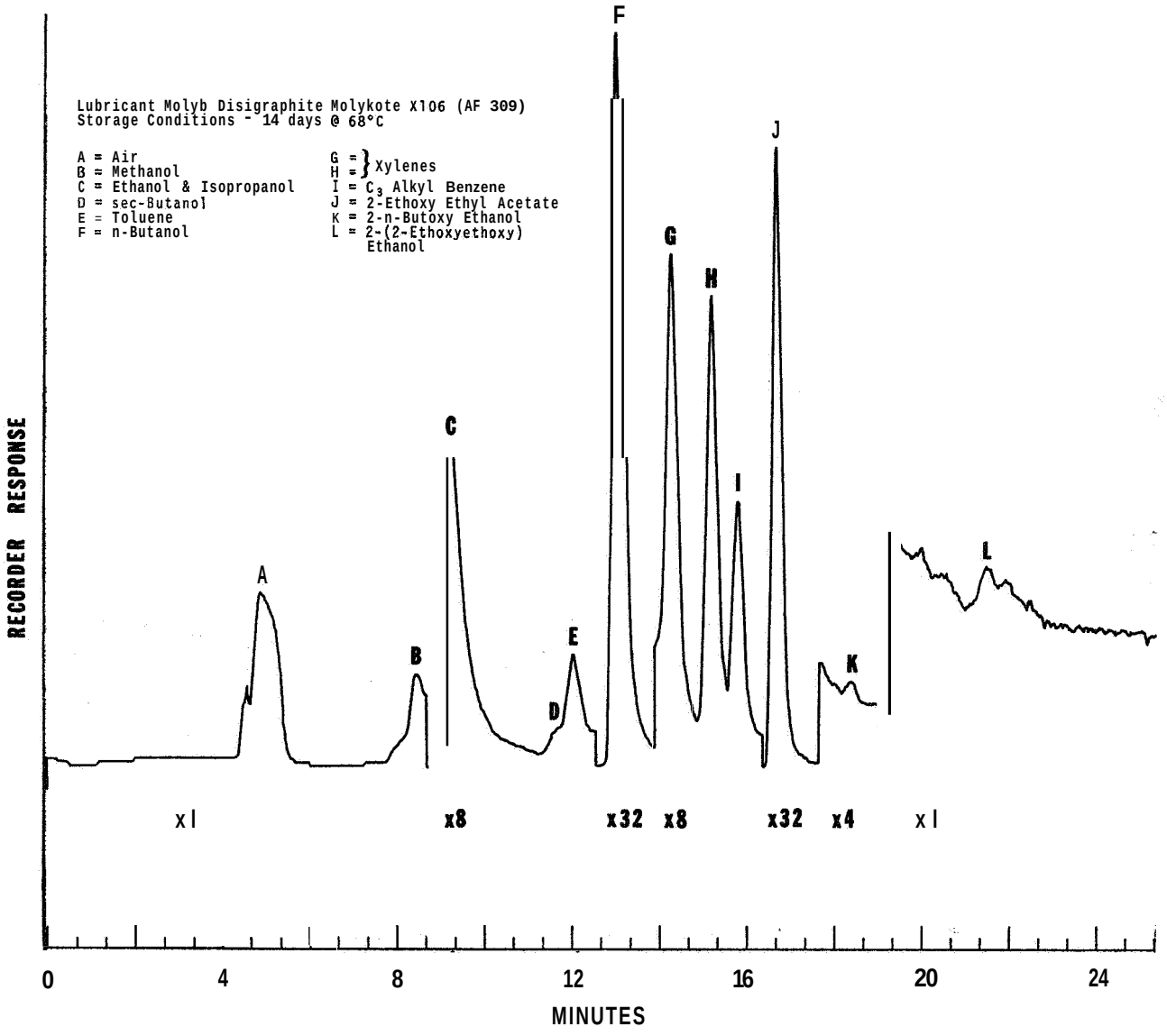

Figure 75. Gas Chromatogram of Gas-Off Products from Lubricant Molyb Disigraphite Molykote X106 (AF 309) (14 days @ 68°C).

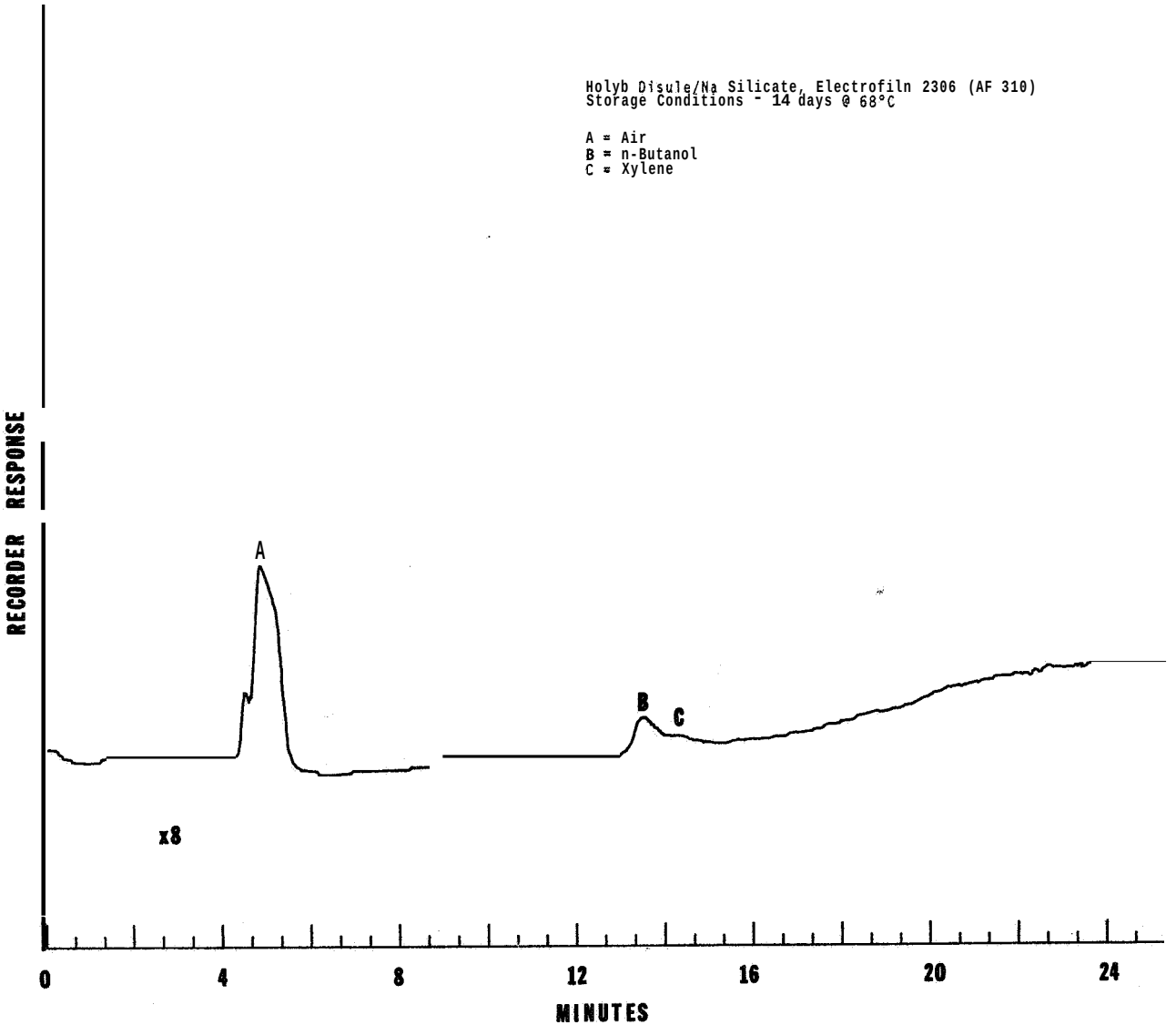

Figure 76. Gas Chromatogram of Gas-Off Products from Molyb Disule/Na Silicate, Electrofilm 2306 (AF 310) (14 days @ 68°C).

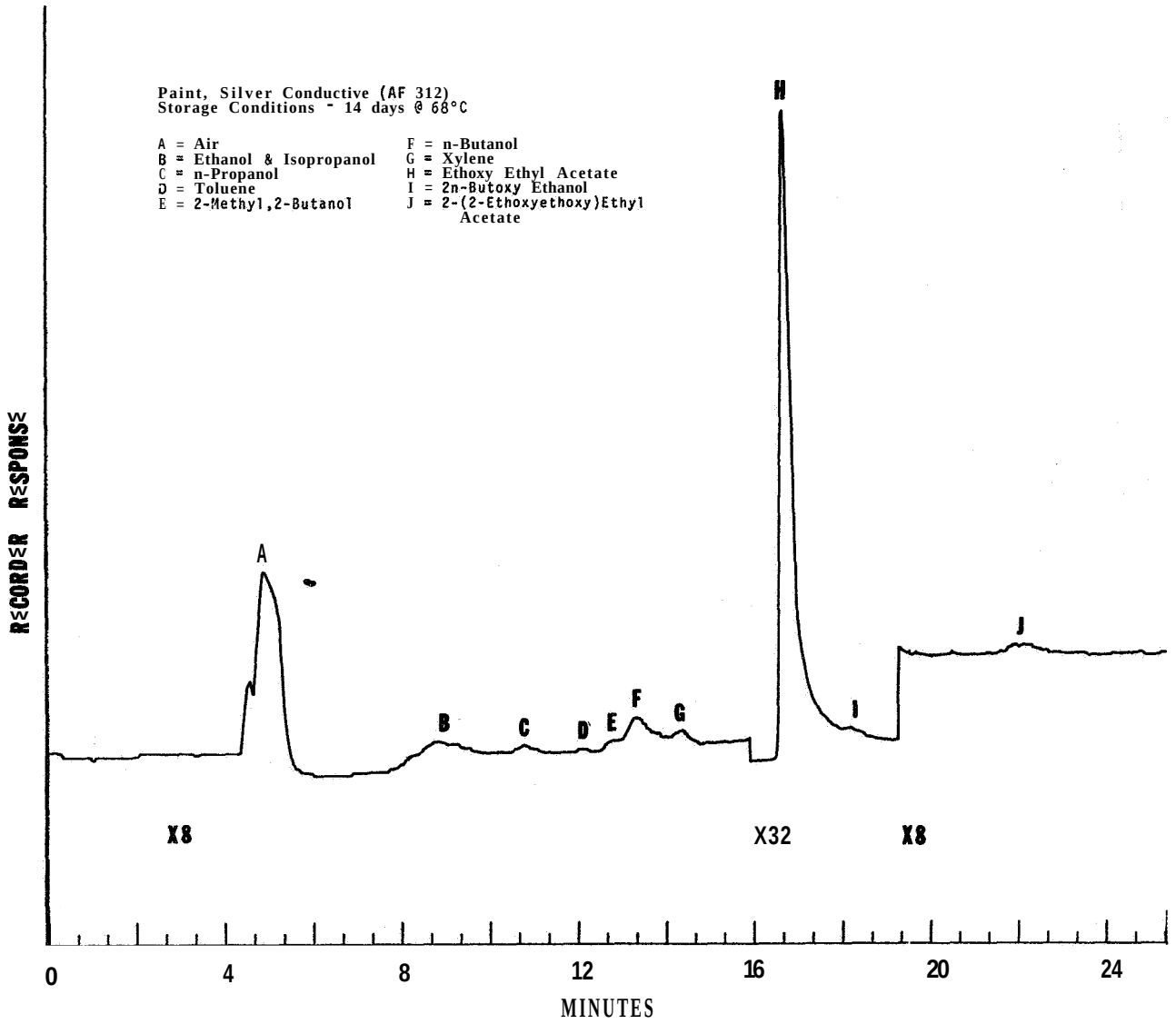

Figure 77. Gas Chromatogram of Gas-Off **Products from** Paint, **Silver Conductive** (AF **312)** (14 days @ 68°C).

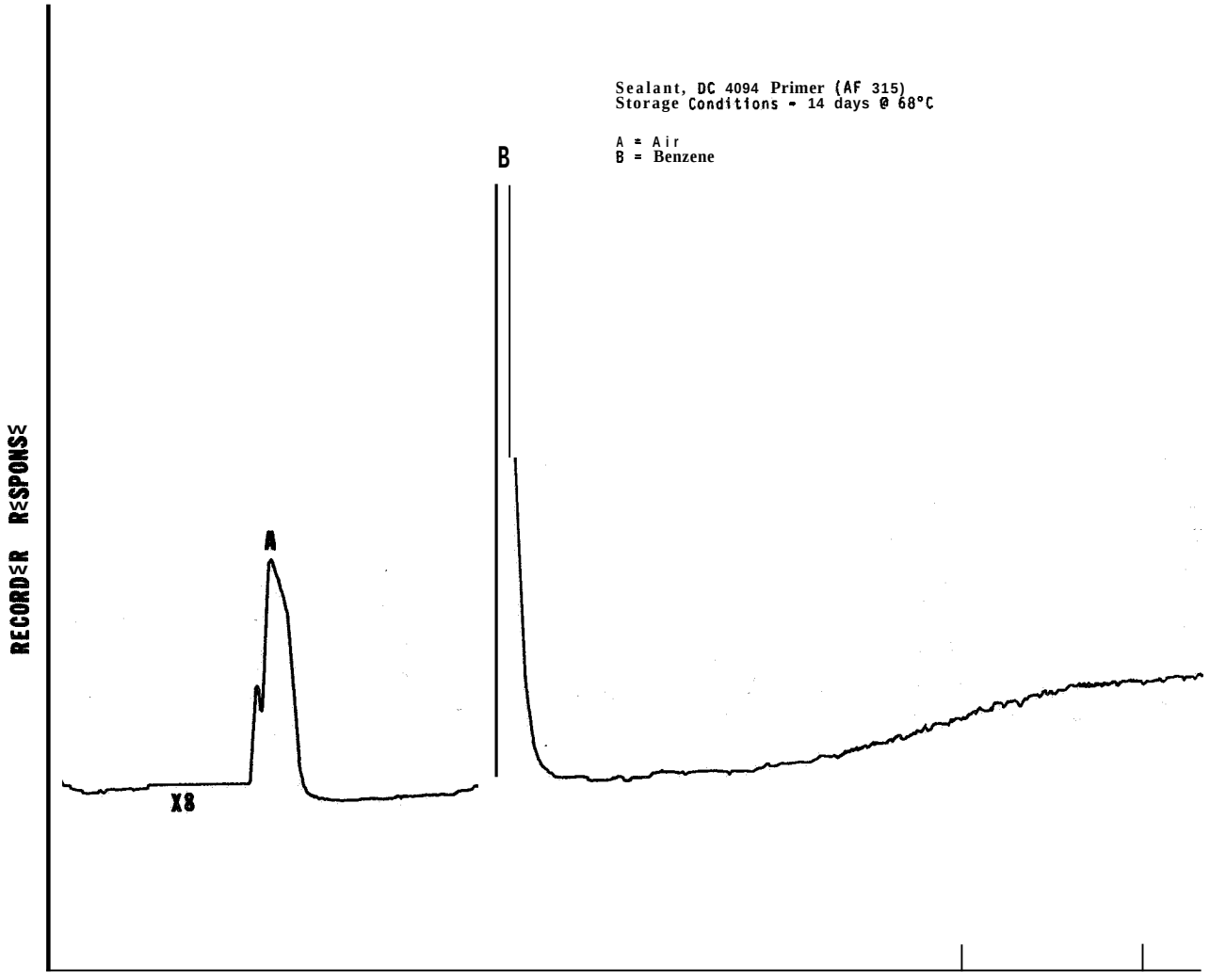

Figure 78. Gas Chromatogram of Gas-Off Products from Sealant, DC 4094 Primer (AF 315) (14 days @ 68°C).

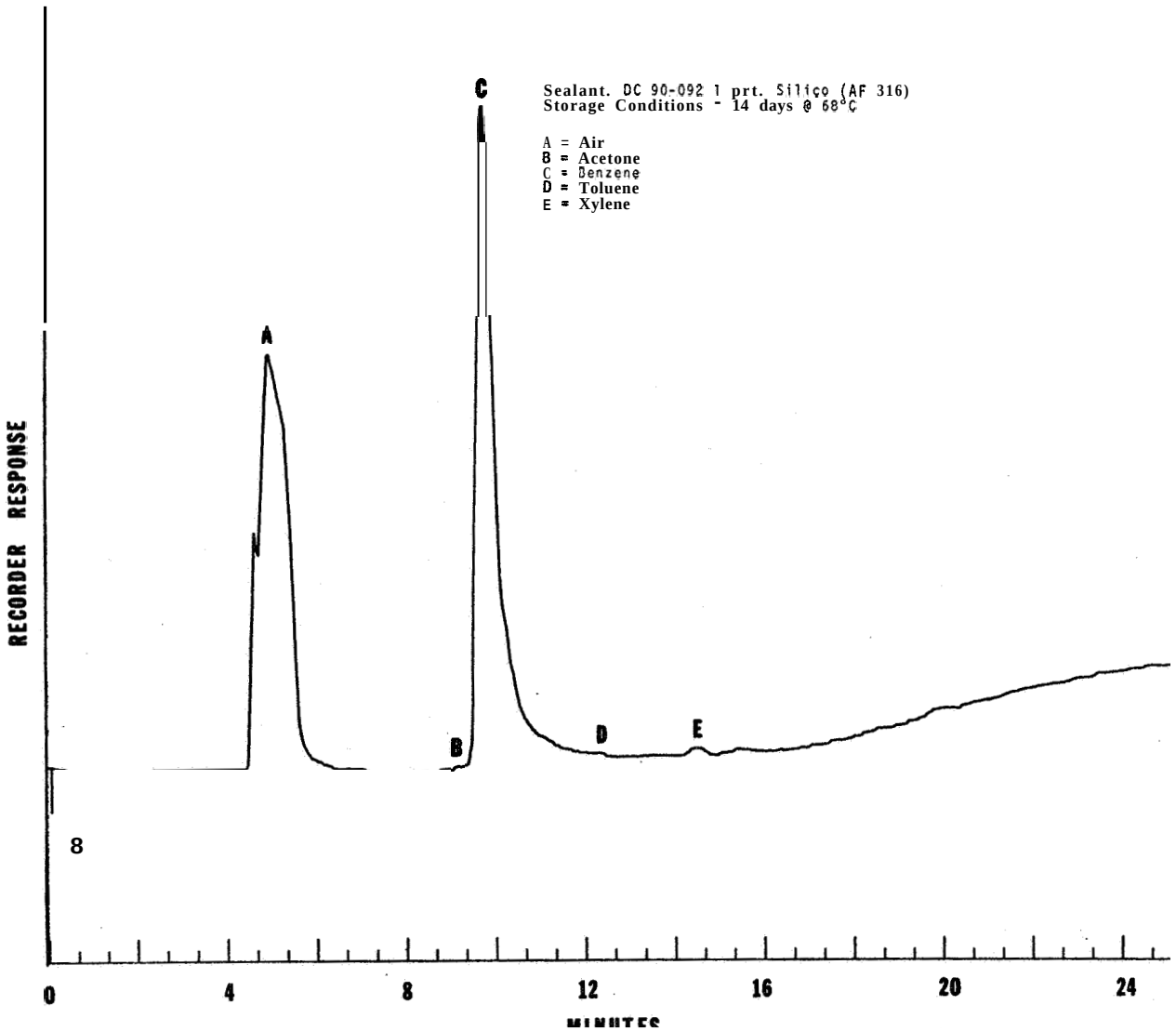

Figure 79. Gas Chromatogram of Gas-Off Products from Sealant, DC 90-092 1prt. Silicone (AF 316) (14 days @ 68°C).

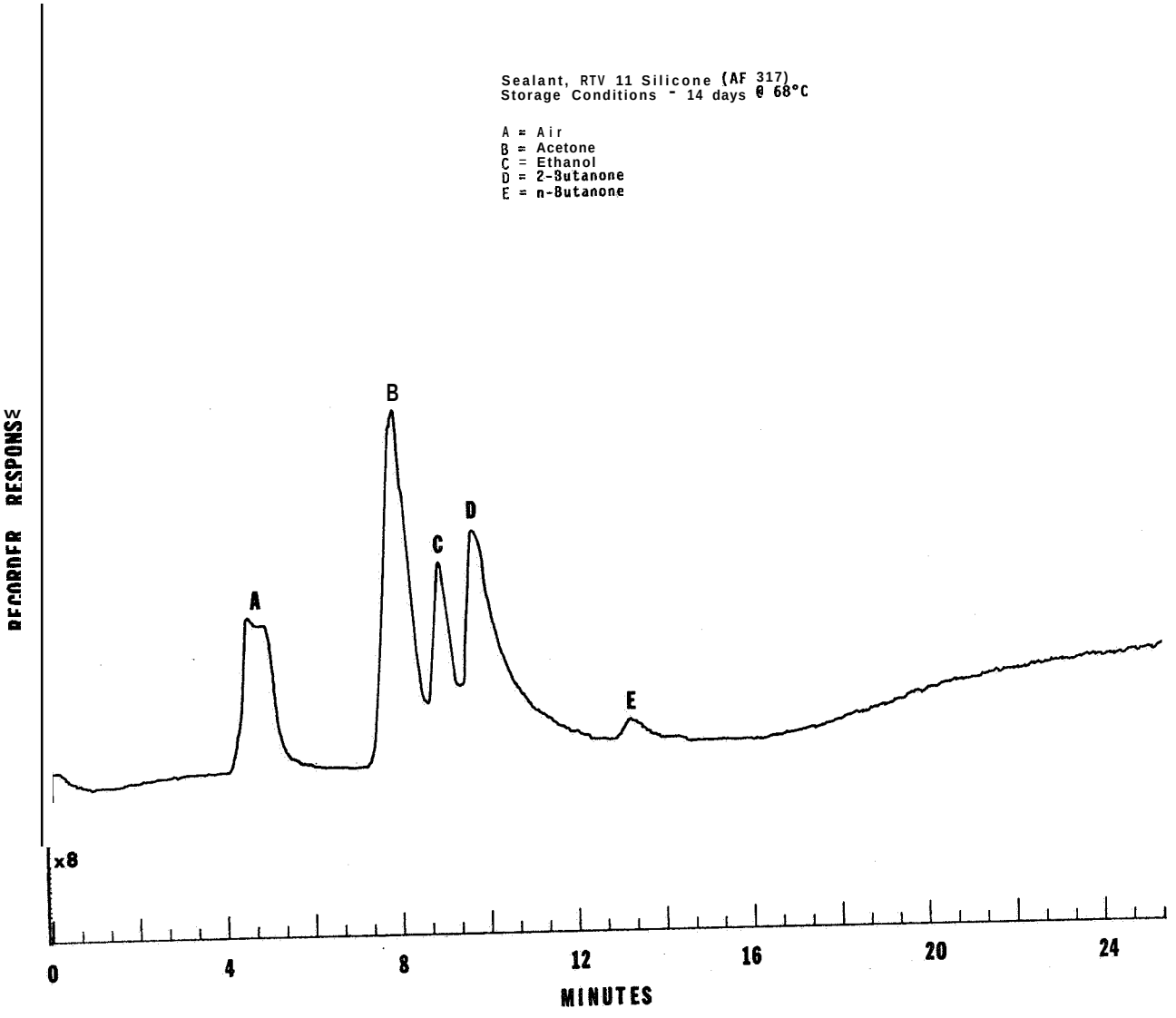

Figure 80. Gas Chromatogram of Gas-Off Products from Sealant, RTV 11 Silicone (AF 317) (14 days @ 68°C).

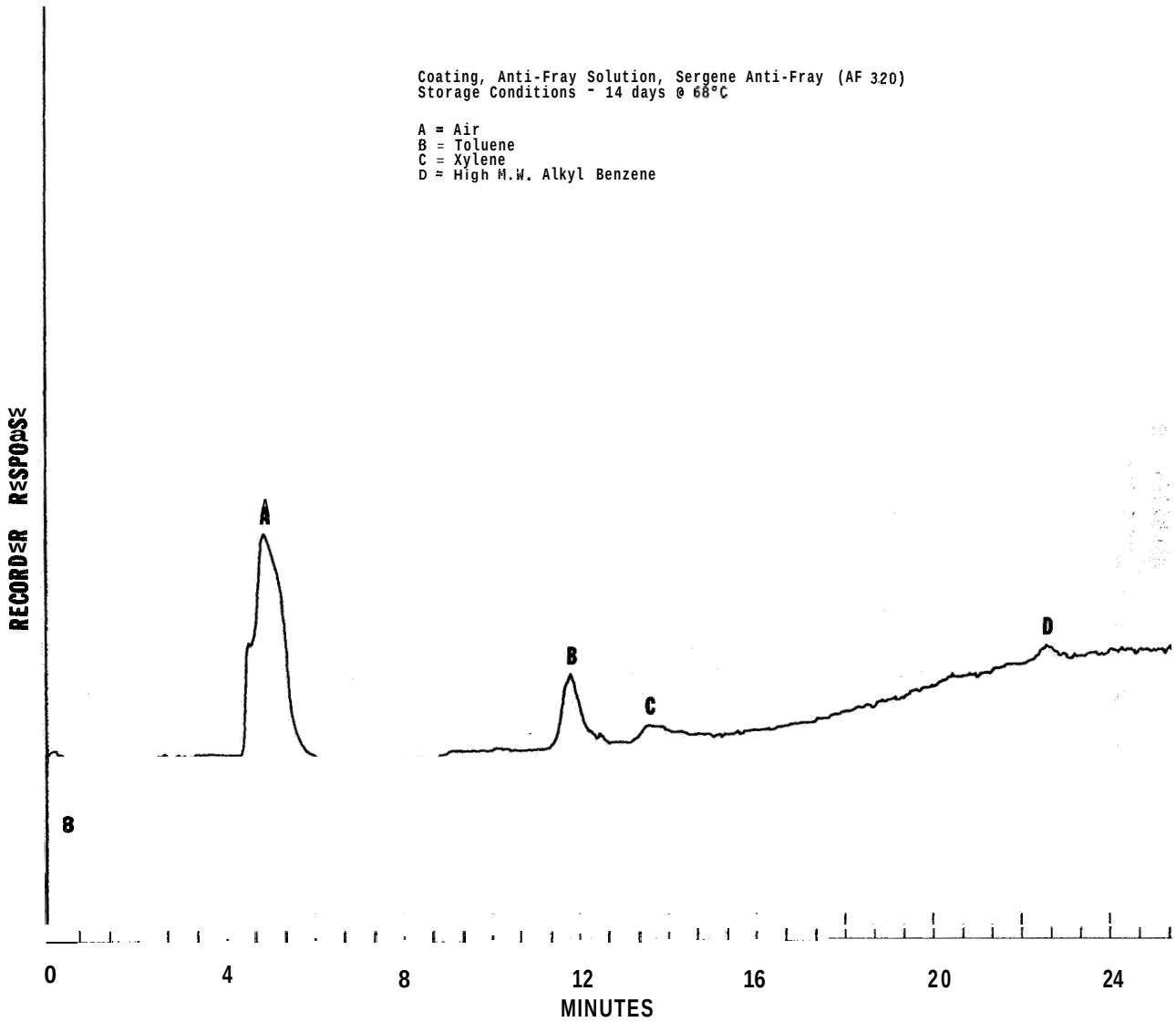

Figure 81. Gas Chromatogram of Gas-Off Products from Coating, Anti-Fray Solution, Sergene Anti-Fray (AF 320) (14 days @ 68°C).

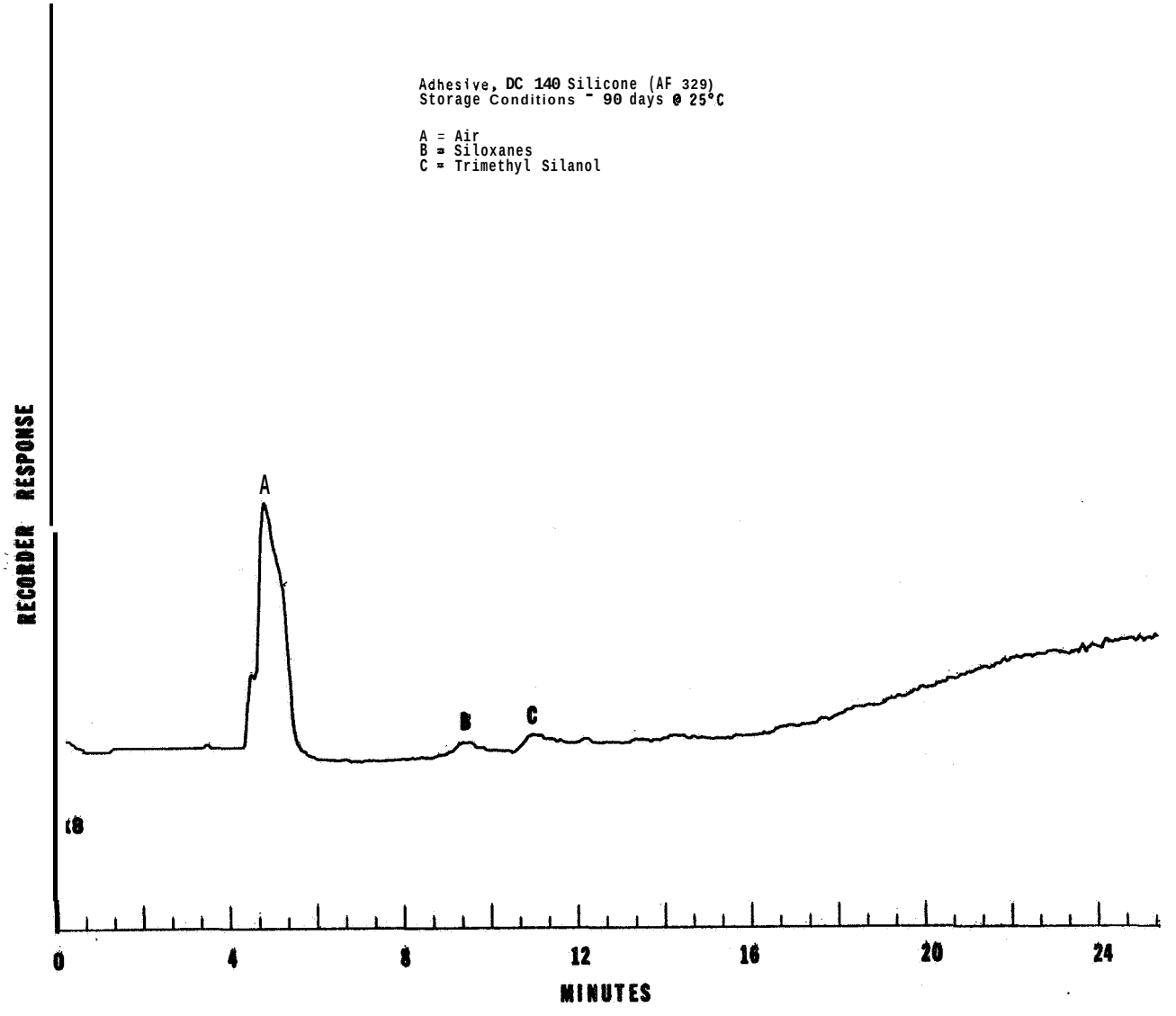

Figure 82. Gas Chromatogram of Gas-Off Products from Adhesive, DC 140 Silicone (AF 329) (90 days @ 25°C).

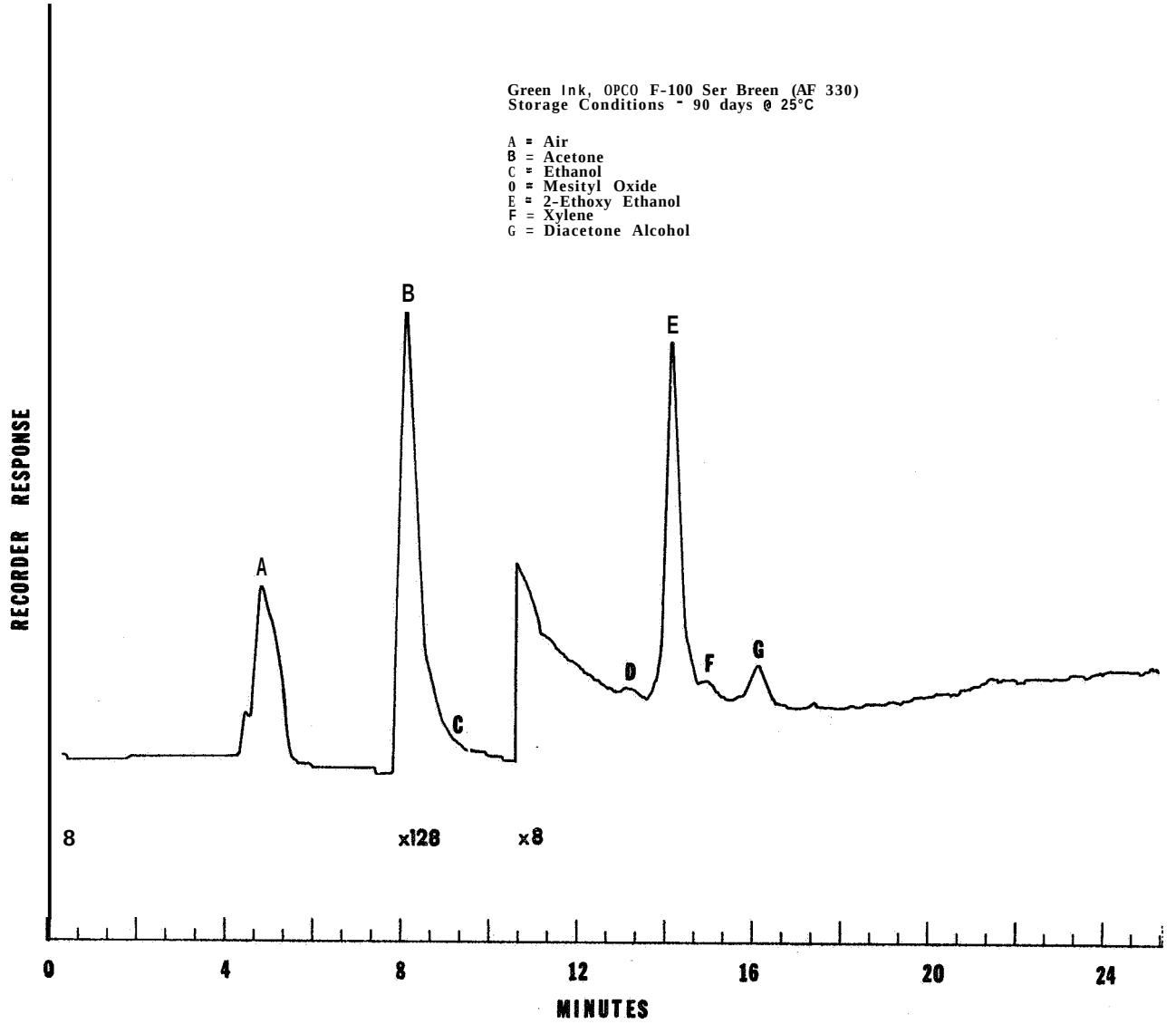

Figure 83. Gas Chromatogram of Gas-Off Products from Green Ink, OPCO F-100 Ser Green (AF 330) (90 days @ 25°C).

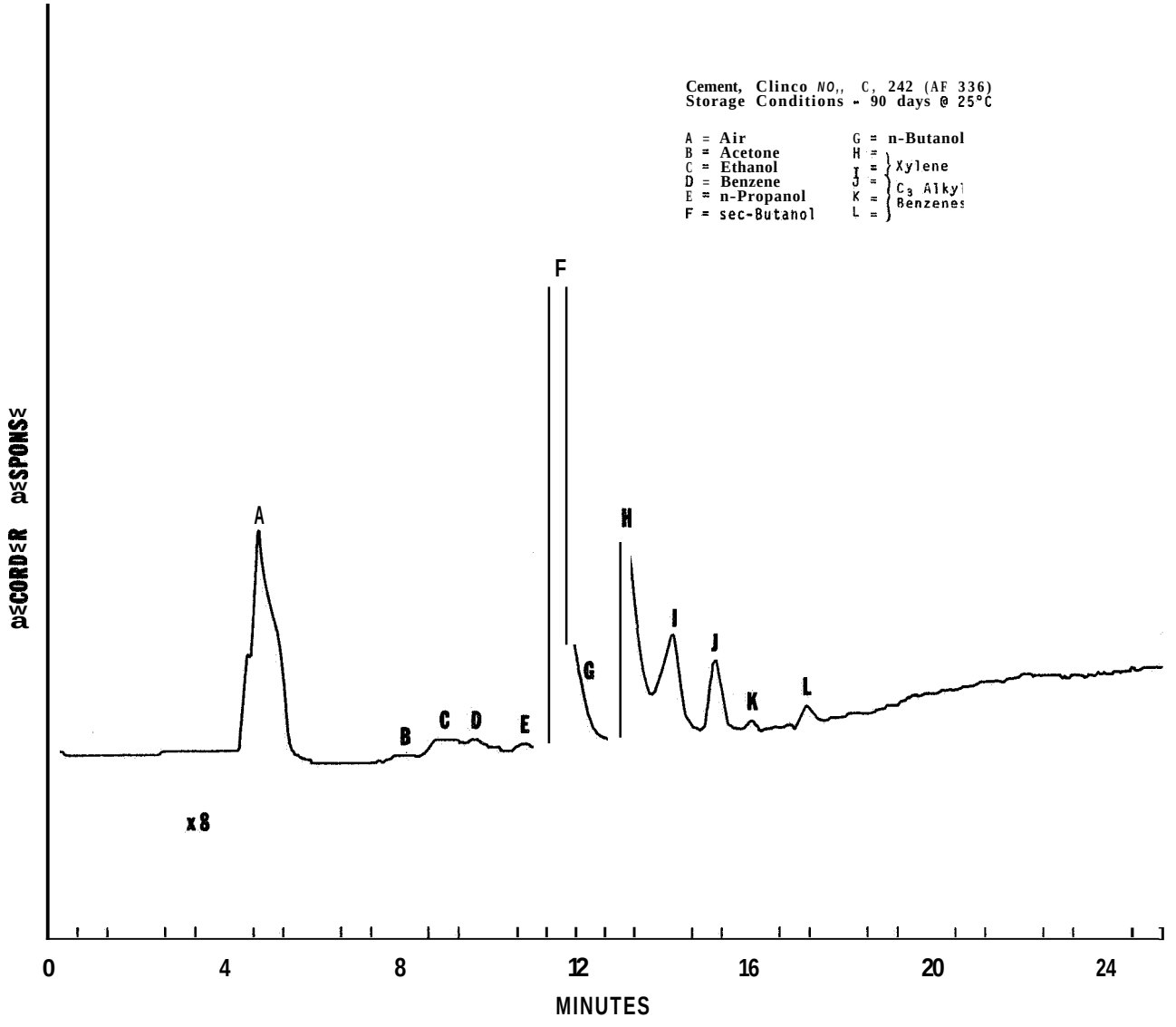

Figure 84. Gas Chromatogram of Gas-Off Products from Cement, Clinco NO_2, C, 242 (AF 336) (90 days @ 25°C).

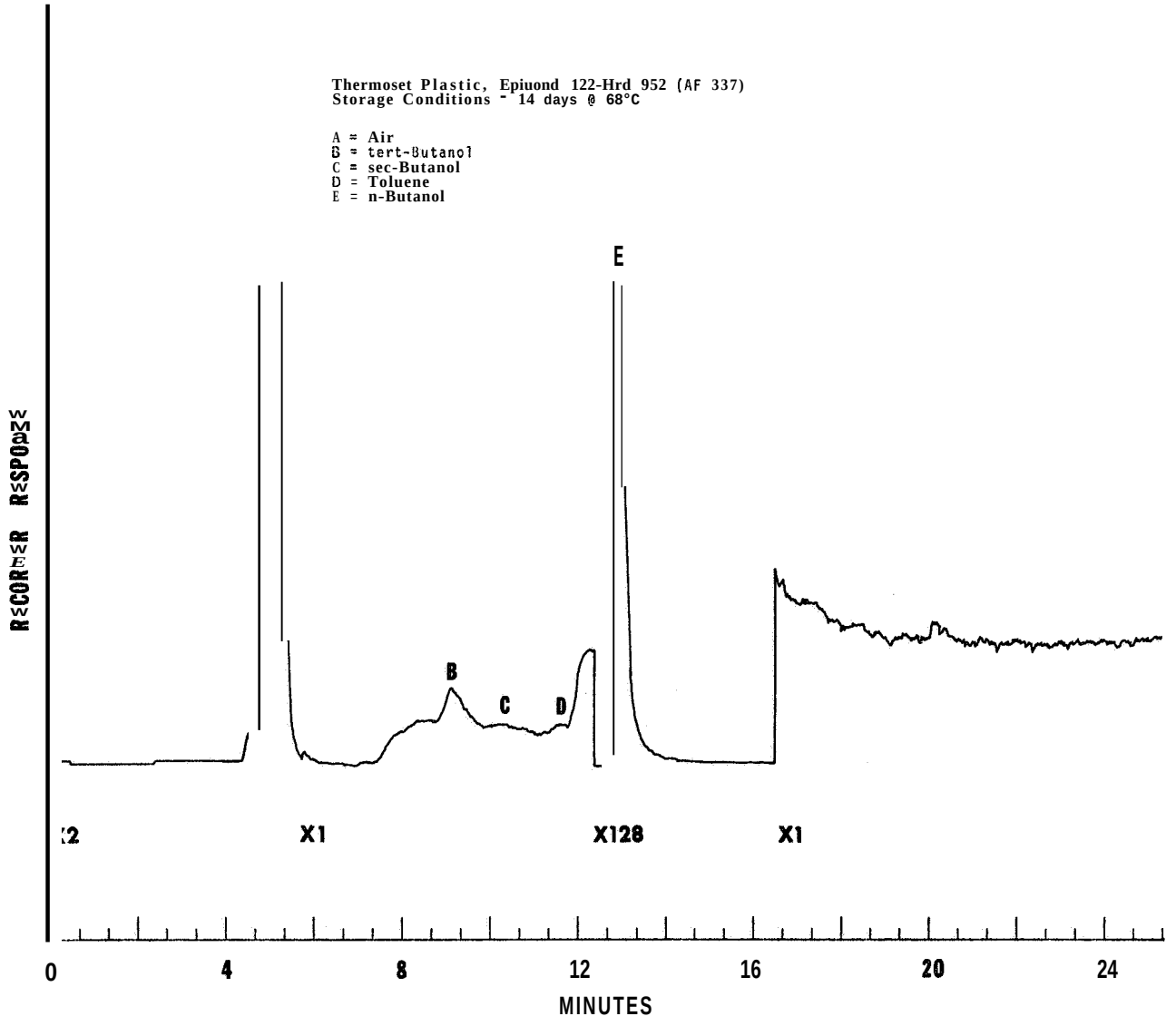

Figure 85. Gas Chromatogram of Gas-Off Products from Thermoset Plastic, Epibond **122-Hrd** 952 (AF 337) (14 days @ 68°C).

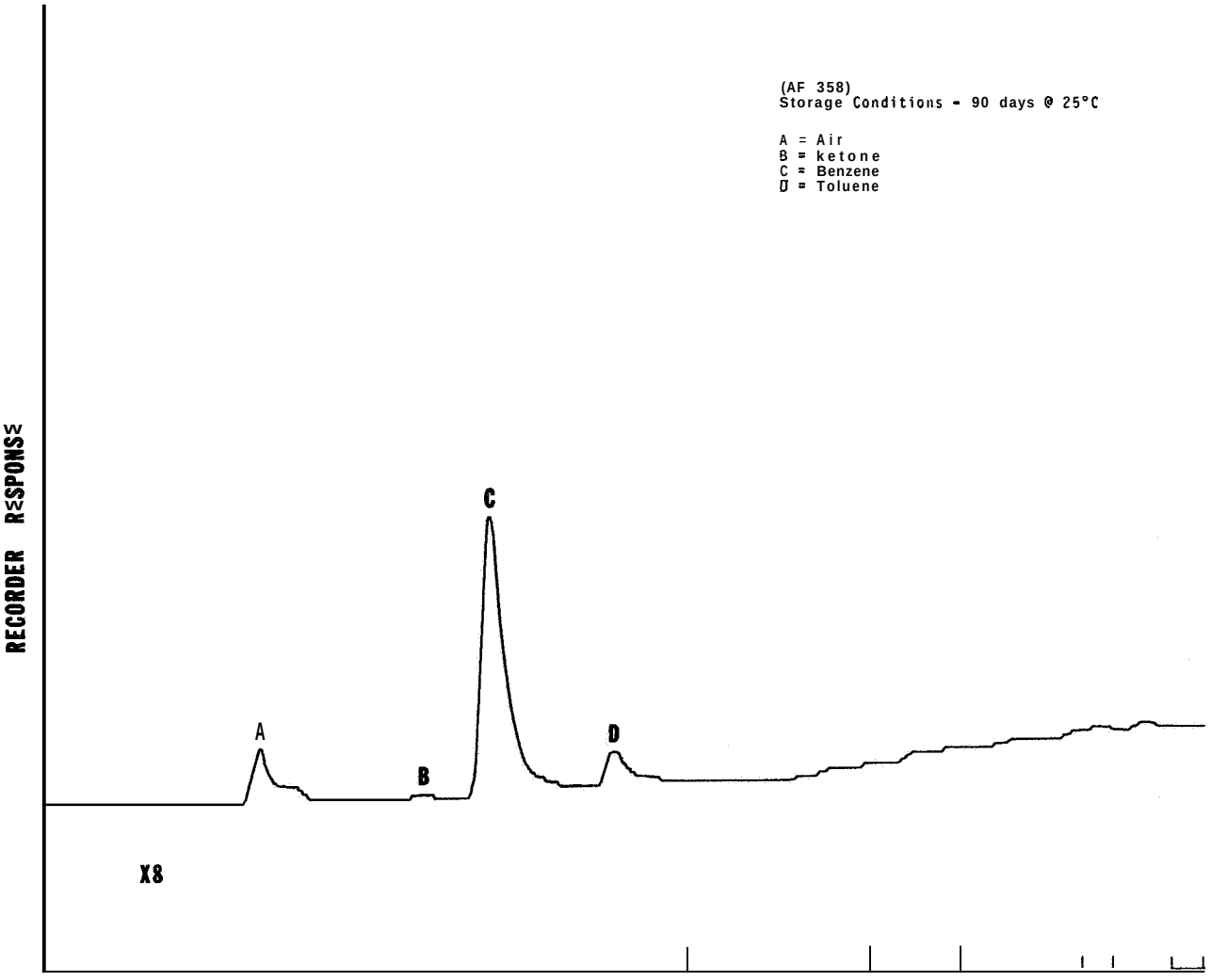

Figure 86. Gas Chromatogram of Gas-Off Products from (AF 358) (90 days @ 25°C).

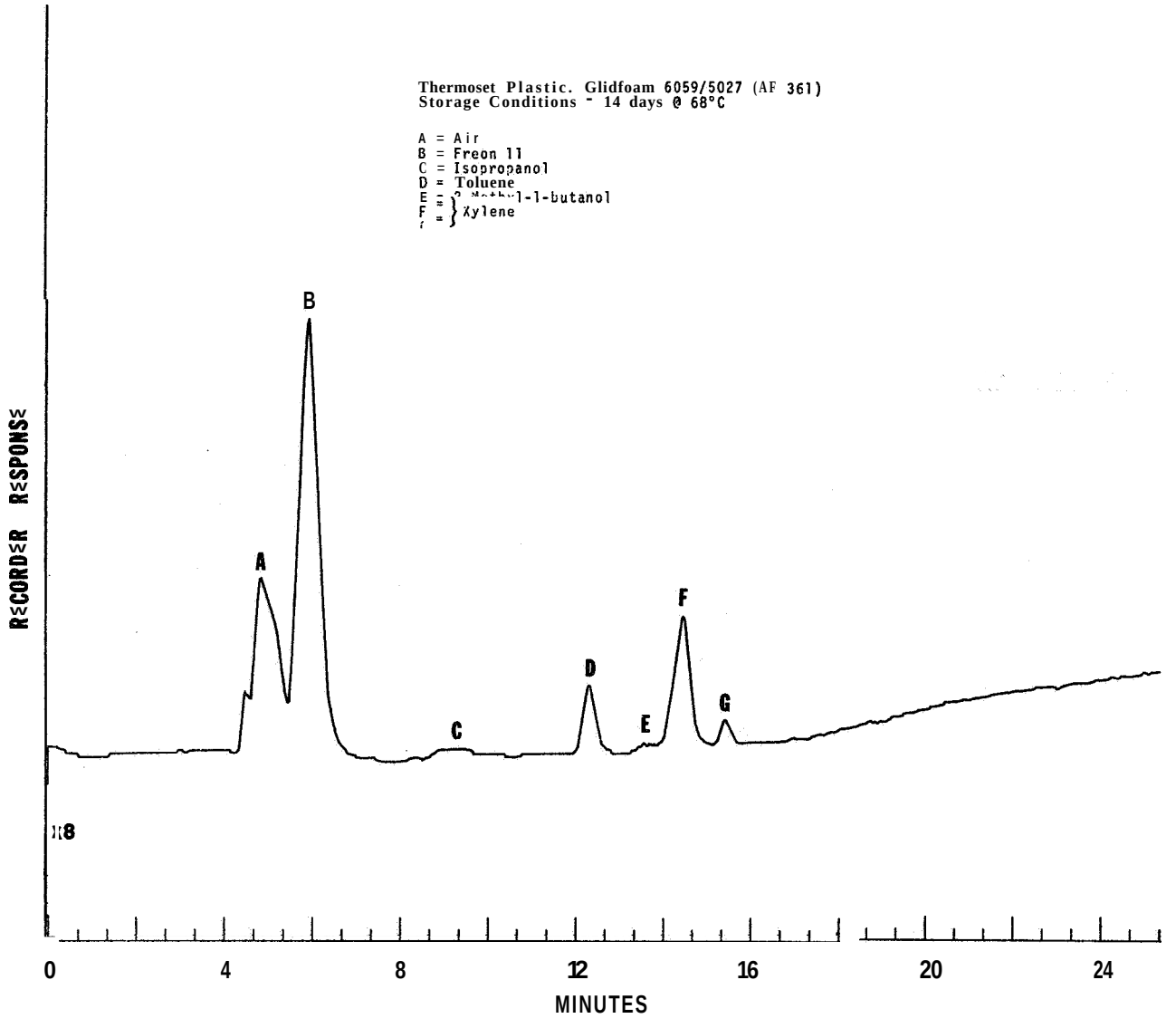

Figure 87. Gas Chromatogram of Gas-Off Products from Thermoset Plastic, Glidfoam 6059/5027 (AF 361) (14 days @ 68°C).

Table XXCV

GAS CHROMATOGRAPHIC INSTRUMENT CONDITIONS

All samples were analyzed using a flame ionization detector and a F&M Model 810 Research Gas Chromatograph.

Instrument Conditions

Column: 12-ft x 1/8-in. O.D., 7% neopentylglycolsuccinate on 60/80 mesh Gas-Pack F + 20-ft x 1/4-in. O.D., 5% Carbowax 20M on 60/80 mesh Gas-Pack F.

Column Temperature: programmed 50°-185°C @ 8°C/min.

Detector Temperature: 275°C

Injection Port Temperature: 250°C

Flow Split: 1:9

Flow Rate: 60 ml/min

Range: 10

Attenuation: X8, or as noted

Sample Size: 25 cc of gas

APPENDIX III

ANALYSES OF BIO-ENVIRONMENTAL ATMOSPHERES

Table XXCVI

ANALYSIS OF ATMOSPHERE OF THOMAS DOME NO. 4
(CONTAINING DOGS AND MONKEYS)

Bio-environmental Sample No. 1

Compound	Level in mg/m^3
Combined methyl and ethyl amines	12
Methane	3
Acetone	4
Carbon monoxide	2
Methylene chloride	8
Benzene	0.2
Toluene	0.1
Xylene	0.2
Diethyl ketone	2
Methyl isobutyl ketone	0.1
Dimethyl formamide (tentative identification)	0.004
Phenol (tentative identification)	0.008
Carbon disulfide	5
Hydrogen sulfide	5
Solid ammonium salts (estimated)	50 mg/m^3

Table XXCVII

ANALYSIS OF CONTAMINATED BREATHING OXYGEN

Bio-environmental Sample No. 2

Impurity	Level (ppm)
Methane	25
Carbon disulfide	20-40

Table XXCVIII

ANALYSIS OF TEST CHAMBER ATMOSPHERES

Bio-environmental Samples No. 3 and No. 4

Component	Level (ppm) Sample No. 3	Sample No. 4
Hydrolysis product of Hydrotherm 700-B*	100	50
"	5	0.5
Trichloroethylene	10	1

*Functional fluid comprised of mixed C_8 silicates.

1. ORIGINATING ACTIVITY *(Corporate author)* Monsanto Research Corporation 1515 Nicholas Road Dayton, Ohio 45407	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP N/A

6. REPORT DATE June 1967	7a. TOTAL NO. OF PAGES 194	7b. NO. OF REFS 1
8a. CONTRACT OR GRANT NO. AF 33(615)-3377 b. PROJECT NO. 6302 c. Task No. 630203 d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* AMRL-TR-67-58	

11. SUPPLEMENTARY NOTES Supported in part by the National Aeronautics & Space Administration under NASA Defense Purchase Request No. T-31248-G.	12. SPONSORING MILITARY ACTIVITY Aerospace Medical Research Laboratories Aerospace Medical Div., Air Force Systems Command, Wright-Patterson AFB, O. 45433

FORM

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Space cabin candidate materials						
Volatile contaminant analyses						
Mass spectrometry						
Gas chromatography						
Cryogenic trapping system						
Bio-environmental analyses						