MAR 26 1982

Docket Nos. 50-272
50-311

MEMORANDUM FOR: Steven A. Varga, Chief
Operating Reactors Branch #1, DL

FROM: William J. Ross, Project Manager
Operating Reactors Branch #1, DL

SUBJECT: MEETING WITH PUBLIC SERVICE ELECTRIC AND GAS COMPANY RELATED TO FIRE PROTECTION AT SALEM UNITS 1 AND 2

On March 8, 1982 representatives of Public Service Electric and Gas Company (the licensee) met with the staff to discuss the need for automatic fire suppression systems in certain areas of Salem Units 1 and 2. A list of participants is enclosed.

In several previous meetings, the licensee had described proposed methods for meeting the requirements of Section G of Appendix R to 10 CFR Part 50, "Fire Protection of Safe Shutdown Capability." In several areas of both Salem Units 1 and 2 cables and equipment and associated non-safety circuits of redundant trains are neither separated by a three-hour barrier nor protected by an automatic fire suppression system as required by III.G.2. The licensee has been attempting to provide an acceptable level of protection without converting the existing manual fire suppression systems to automatic.

During this meeting the licensee and consultant described a model for analyzing fire loading and demonstrated how this model could be used to predict the expected fire severity of rooms with the plant. This presentation is summarized in Enclosure 2.

The staff agreed that the model indicated that the fire severity in most of the areas under consideration could be maintained at an acceptable level for 30 minutes, without the use of an automatic suppression system, until the fire brigade can begin to fight the fire. However, the staff was not convinced that the model suffices for all rooms, configurations, or ventilation systems. The 4kv switchgear rooms and the electrical penetration rooms were identified as two areas where the model's results were suspect.

OFFICE ▶							
SURNAME ▶							
DATE ▶							

The staff requested the licensee to provide, within three weeks, further justification that all rooms could be protected without an automatic suppression system (as demonstrated by their model) or alternative means of meeting the requirements of Section G. The staff also advised the licensee that we have reservations related to the use of carbon dioxide suppression systems, especially manual systems but we would be willing to discuss all options.

William J. Ross, Project Manager
Operating Reactors Branch #1
Division of Licensing

Enclosures:
As stated

OFFICE	DL:ORB#1						
SURNAME	WJRoss/ms						
DATE	3/26/82						

MAR 26 1982

MEETING SUMMARY
OPERATING REACTORS BRANCH NO. 1
DIVISION OF LICENSING

Docket File
NRC PDR
Local PDR
ORB 1 File
J. Heltemes, AEOD
B. Grimes
S. Varga
Project Manager
OELD
OI&E (1)
ACRS (10)
NRC Participants
NSIC

cc: Licensee with
Service List

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Ronald C. Haynes
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Enclosure 1

Participants

NRC

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J. Stang
W. Ross
R. Eberle

Licensee

W. Pavincich
G. Supplee
M. Swann (Protopower)

SALEM GENERATING STATION FIRE HAZARD ANALYSIS

OBJECTIVE: Develop a practical tool for predicting the expected fire severity of rooms within the Salem Generating Station consistent with recognized fire hazard analyses and test data.

This tool will serve as the basis for area by area exemption requests for employing one hour rated fire barriers without automatically initiated suppression systems.

METHODOLOGY: Employing the recently developed computer program, establish if a satisfactory correlation between equivalent ASTM E-119 fire severity and combustible fire load density exists. Compare values with NFPA Fire Protection Handbook Table 6-8A.

TABLE 6-8A. Estimated Fire Severity for Offices and Light Commercial Occupancies

Data applying to fire-resistive buildings with combustible furniture and shelving

Combustible Content Total, including finish, floor, and trim psf	F_f Heat Potential Assumed* Btu per sq.ft. ($x10^3$)	Equivalent Fire Severity Approximately equivalent to that of test under standard curve for the following periods:
5	40	30 min.
10	80	1 hr.
15	120	1½
20	160	2
30	240	3
40	320	4½
50	380	7
60	432	8
70	500	9

*Heat of combustion and weights of combustibles correspond to ordinary combustible materials such as wood, paper, or textiles.

COMPUTER PROGRAM DESCRIPTION:

SUMMARY: The program conducts a transient energy and mass balance for given combustibles and room configurations to produce an approximate room air temperature - time profile. This profile is used to establish a fire rating by determining its equivalency to the ASTM E-119 fire test curve.

NEW CHANGES:

- o Revised heat of combustion values (H_A) to be consistent with available test data and other analyses.

  - Heptane, $H_A = 44.56$ KJ/g[1] for complete combustion.

    $H'_A = 30.75$ KJ/g[1] net, actual. ≈ 73,000 BTU/gallon

  (Cable) - EPR/Hypalon, $H_A = 17.4-29.6$ KJ/g[1] for complete combustion.

    $H'_A = \eta_c H_A$

    $\eta_c = 0.5$[2]

    $H'_A = 14.8$ KJ/g net, actual 6400 BTU/lb.

o Revised actual heat release rates ($\dot{Q}''_A$) to be consistent with available test data.

- Heptane, heat release rate = $\dot{Q}''_A$ = 2700 KW/m^2 (1) = 239 Btu/sec-ft^2

  linear regression rate = 4 mm/min (3) $\Rightarrow$ $\dot{Q}''_A$ = 120 Btu/sec-ft^2

  convective fraction = 67% (1)

  radiative fraction = 33% (1)

- EPR/Hypalon, $\dot{Q}''_A$ = 180-350 KW/m^2 (1) = 15.9-30.8 Btu/sec-ft^2

  convective fraction = 38-65% (1) X_c = 67%

  radiative fraction = 62-35% (1) X_r = 33%

  $\dot{Q}''_A = H'_A/30$ min. = 3.54 Btu/sec-lbm. =

SALIENT POINTS:

- Ignition of all in situ combustibles is made to occur almost spontaneously within a few seconds of transient combustible ignition.
- Cable heat release rate, $\dot{Q}_A'' = 3.54$ Btu/sec-lbm, is highly conservative if all the cabling is assumed to be burning simultaneously.
- Radiative fraction of 1/3 is consistent with generally recognized fire characteristics.
- Convective heat transfer coefficient assumes laminar flow past boundary surfaces; actual mode is generally turbulent.

RESULTS:

- Typical time-temperature profile, Figure 1.

- Selected burn rate provides conservative results. Effect of different burn rates is depicted in Figure 2.

- Unsuccessful correlation of floor fire load density with equivalent E-119 fire severity, Figure 3.

- Successful correlation using the total boundary area fire load density, $t_E = 0.168\ F_b^{0.605}$.

  - The maximum acceptable fire load density, $F_b \approx 5000$ Btu/ft^2 boundary area.

  - Rooms for which an exemption is requested meet this criteria.

  - The ASTM E-119 fire test curve converted to the 250°F base is described by the equation, $t_E = 0.055\ U^{0.621}$ for $5 \leq t_E \leq 60$ min, Figure 5. The near equality of the exponents for this equation and that for the correlation curve, verifies a direct relationship between the fire load density and the integral of the fire test curve.

  - The correlation is not without precedence. Theoretical studies in Sweden[4] have led to the same conclusion.

APPLICABILITY OF CORRELATION:

- o Non-ventilation controlled fires.
- o Similar boundary material thermal properties and thicknesses.
- o Approximately similar room geometries, $3 \leq R \leq 8$.

SUMMARY:

- o Utilizing the developed computer program, a successful correlation between fire load density based on total boundary surface area and equivalent E-119 fire severity has been obtained.
- o The rooms of the Salem Generating Station for which an exemption is requested meet the fire load density criteria.

NOMENCLATURE

A_b = Total room boundary surface area (l^2).

A_f = Room floor area (l^2).

F_b = Fire load density based on total boundary area, Q_T/A_b, (E/l^2).

F_f = Fire load density based on floor area, Q_T/A_f, (E/l^2).

H_A = Actual heat of combustion for complete combustion (E/M).

H_A' = Net, actual heat of combustion (incomplete combustion) (E/M).

R = Room geometry coefficient, A_b/A_f (-).

Q_T = Total combustible fire load (E).

$\dot{Q}_A''$ = Net heat release rate (E/t).

t_E = Equivalent ASTM E-119 fire severity (t).

U = Integral of ASTM E-119 fire test curve (t-T).

X_c = Convective fraction (-).

X_r = Radiative fraction (-).

η_c = Combustion efficiency (-).

REFERENCES

(1) Tewarson, A., "Damageability and Combustibility of Electrical Cables", Factory Mutual Research Corp.

(2) "NRC Twenty Foot Separation Fire Test Plan", Edison Electric Institute.

(3) Burgess, D. and Hertzberg, M., "Radiation from Pool Flames", U.S. Dept. of Interior, Bureau of Mines.

(4) Odeen, K., "Theoretical Study of Fire Characteristics in Enclosed Spaces", Bulletin 10, Division of Building Construction, Royal Institute of Technology, Stockholm.

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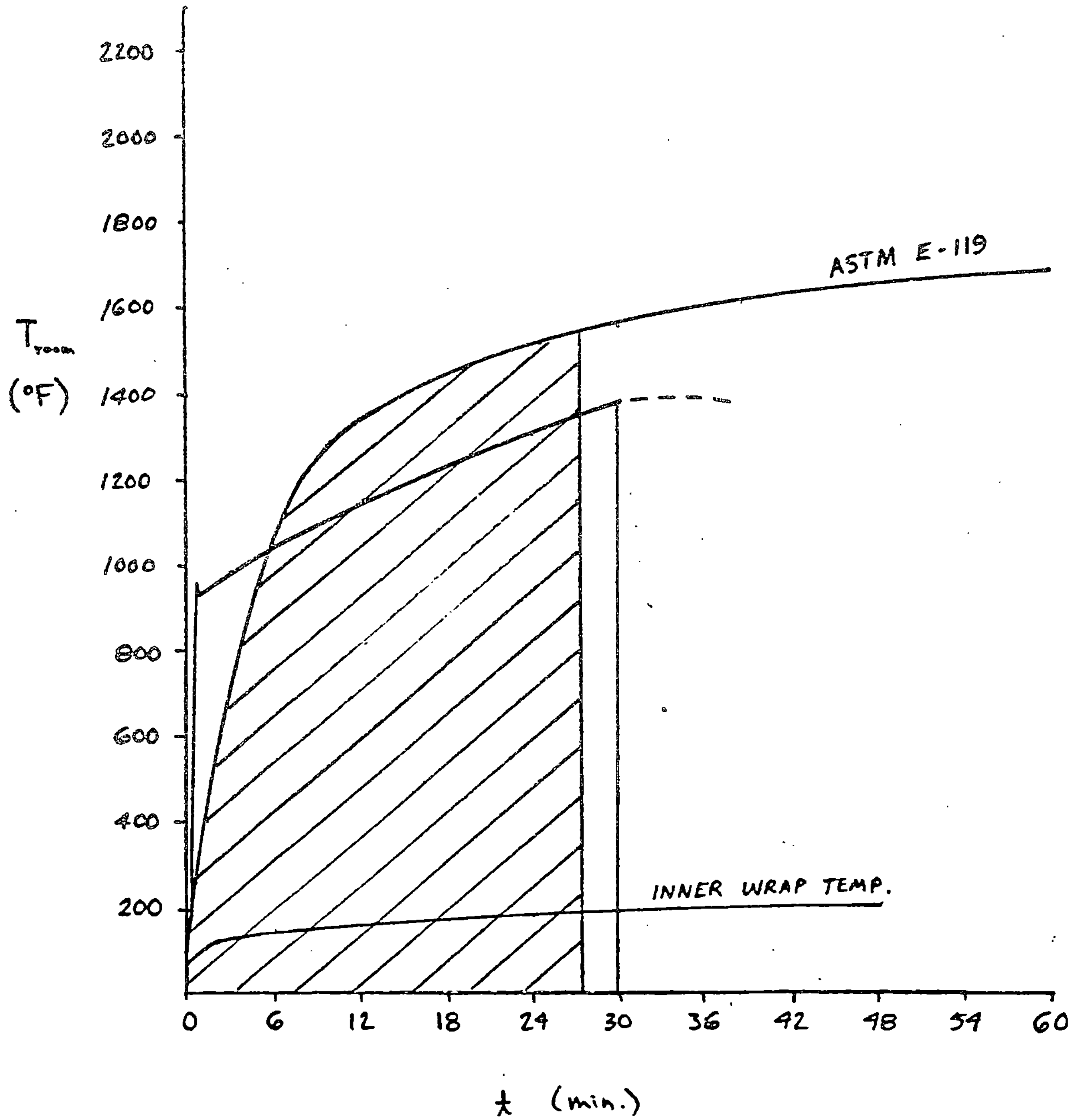

FIG. 1 P2F-1 TEMP-TIME PROFILE

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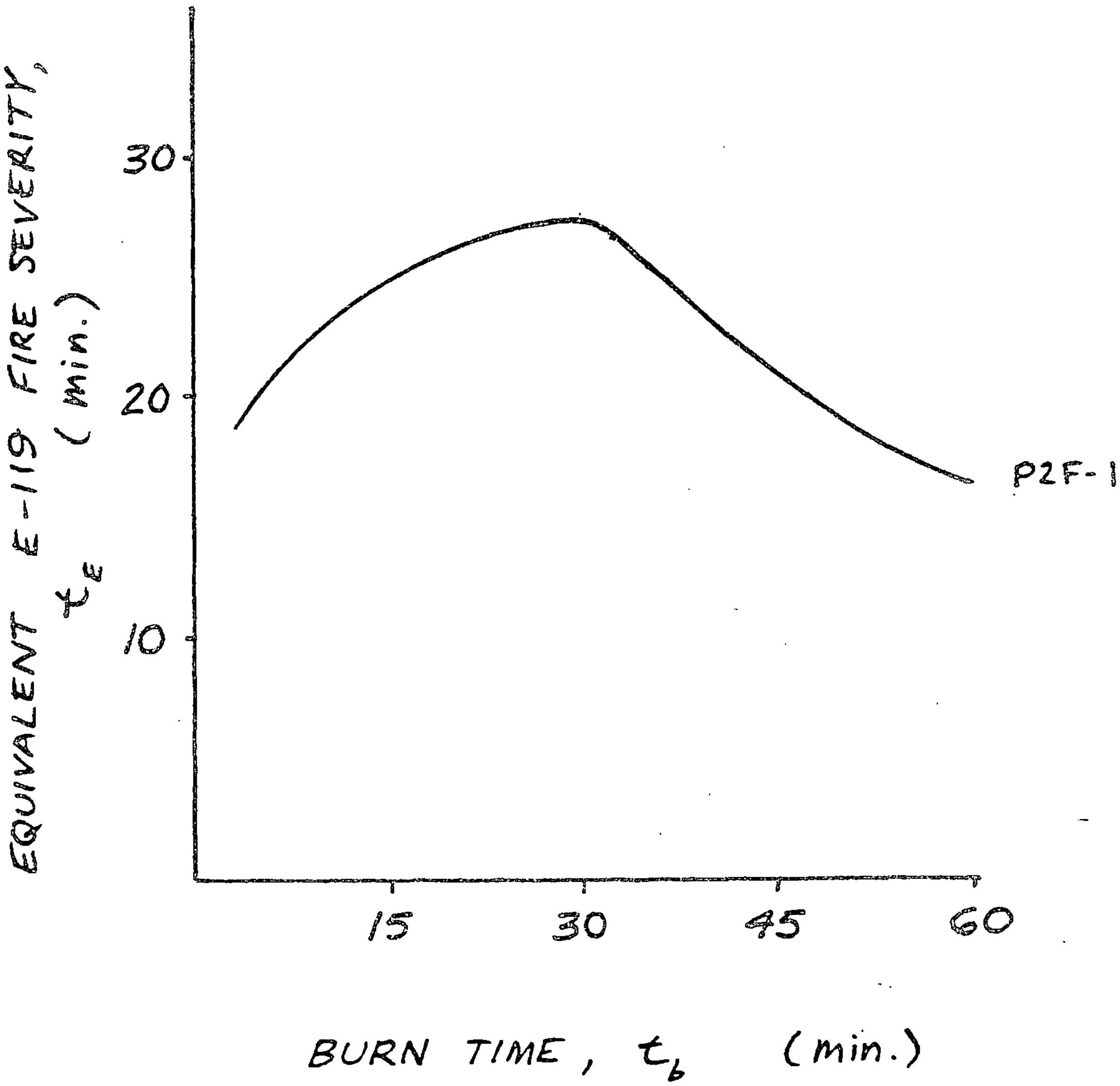

FIG. 2. EFFECT OF CABLE BURN RATE

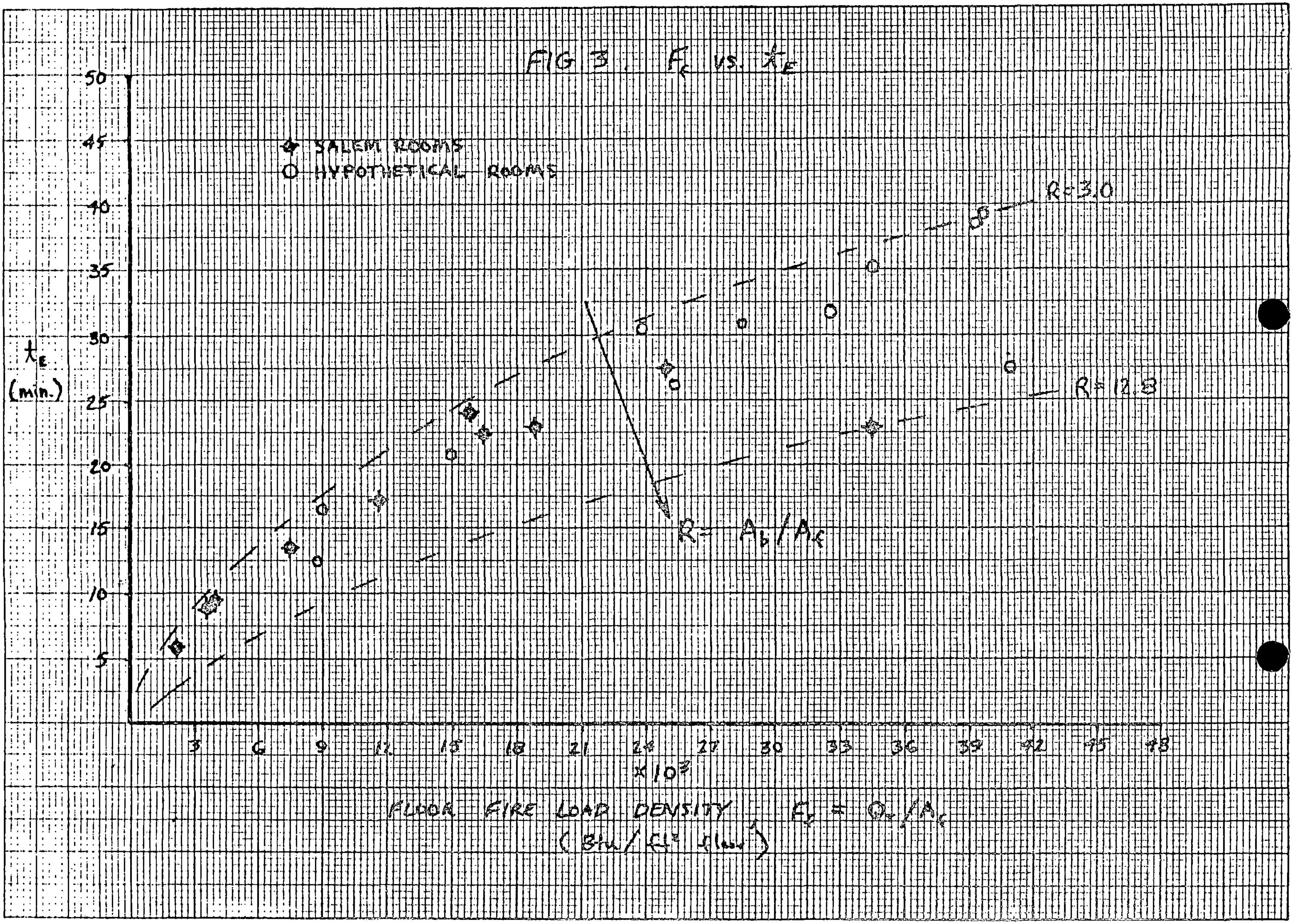
FIG 3. F_c vs. t_E
SALEM ROOMS
HYPOTHETICAL ROOMS
R=3.0
R=12.8
$R = A_b / A_c$
t_E (min.)
50
45
40
35
30
25
20
15
10
5
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
$\times 10^3$
FLOOR FIRE LOAD DENSITY $F_c = Q_c / A_c$
(Btu / ft² floor)

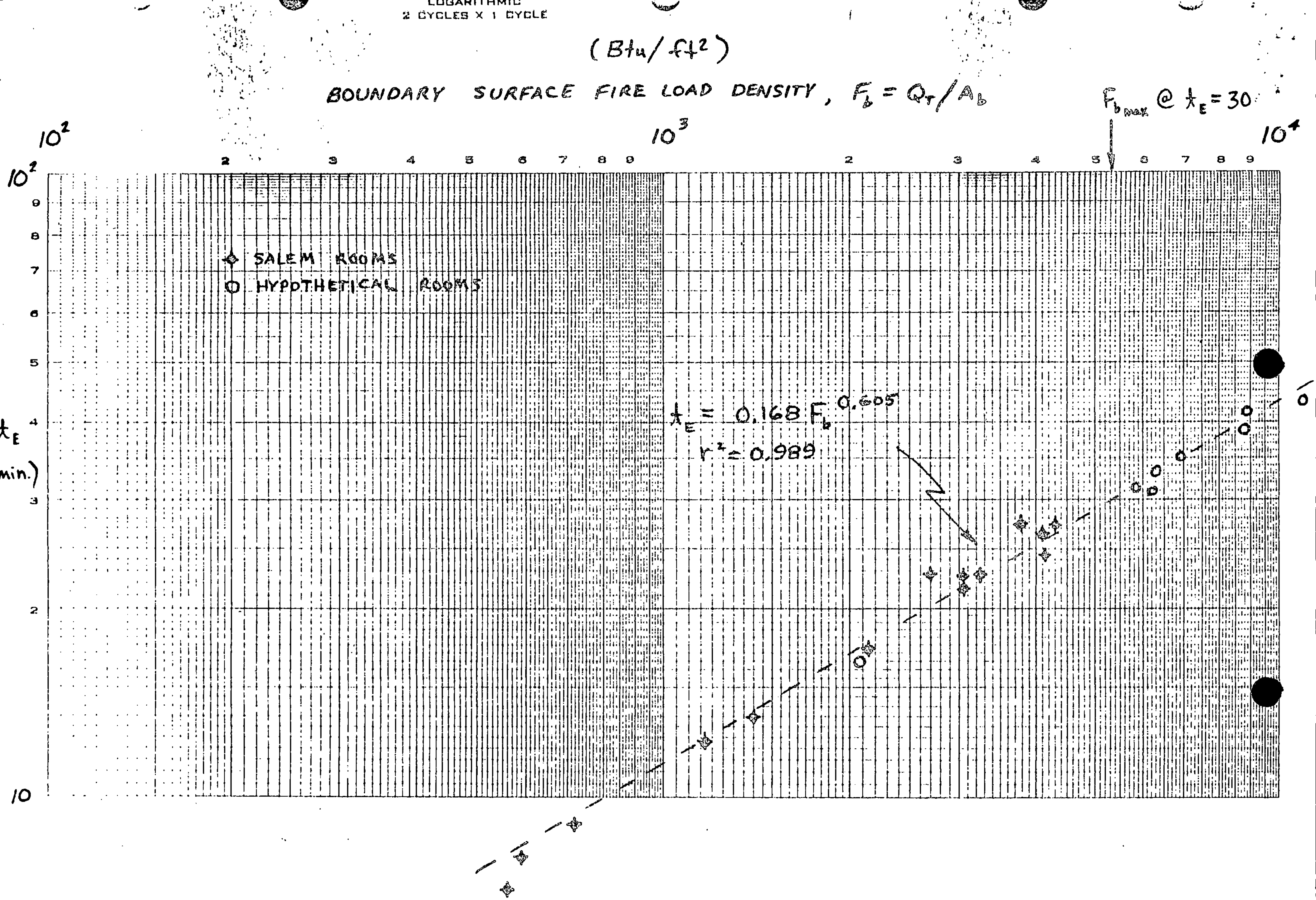
LOGARITHMIC
2 CYCLES X 1 CYCLE
(Btu/ft²)
BOUNDARY SURFACE FIRE LOAD DENSITY, $F_b = Q_T/A_b$
$F_{b_{max}}$ @ $t_E = 30$
t_E
(min.)
SALEM ROOMS
HYPOTHETICAL ROOMS
$t_E = 0.168 F_b^{0.605}$
$r^2 = 0.989$

FIG. 4. F_b vs. t_E

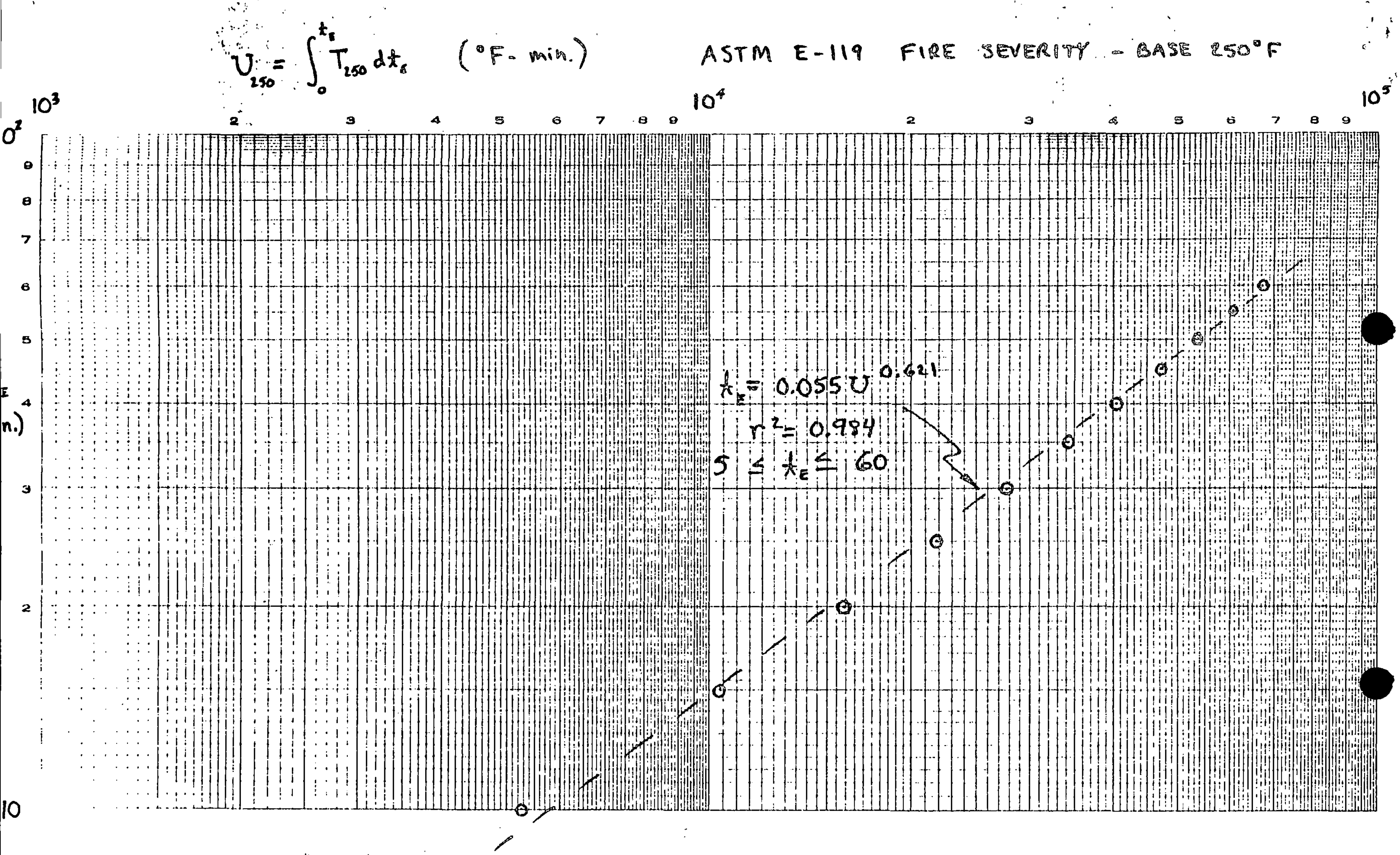

FIG. 5. U_{250} vs. t_E