

**TMI-1 UFSAR**

APPENDIX 5A

GILBERT ASSOCIATES, INC., REPORT

TO

METROPOLITAN EDISON COMPANY

ON

SUMMARY OF AIRCRAFT IMPACT DESIGN

FOR

THREE MILE ISLAND NUCLEAR STATION  
UNIT 1

This Report Contains:

5 pages of text  
7 tables  
42 figures

# TMI-1 UFSAR

## TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>
1	<u>INTRODUCTION</u>
2	<u>DYNAMIC LOAD FACTORS</u>
3	<u>ANALYSIS</u>
3.1	<u>SHELL ANALYSIS</u>
3.1.1	APEX OF THE DOME
3.1.1.1	ANALYSIS FOR CASE A & B IMPACT LOADINGS
3.1.1.1.1	STRUCTURAL RESPONSE
3.1.1.1.2	LOCAL MATERIAL FAILURE
3.1.1.2	ANALYSIS FOR CASE C IMPACT LOADING
3.1.1.3	ANALYSIS FOR CASE D IMPACT LOADING
3.1.2	DOMES TO GIRDER TRANSITION
3.1.3	GIRDER TO CYLINDER TRANSITION (SPRING LINE)
3.1.4	IMPACT AT GRADE
3.2	<u>PLATE ANALYSIS</u>
3.2.1	FUNDAMENTAL FREQUENCY
3.2.2	FINITE-ELEMENT ANALYSIS FOR SLABS
3.2.3	DESIGN CRITERIA FOR REINFORCING
3.2.4	DESIGN CHECK
4	<u>ADDITIONAL DETAIL STUDIES</u>
4.1	<u>BEARING FAILURE OF CONCRETE UNDER DIRECT IMPACT</u>
4.2	<u>SHEAR-OFF THE ANCHORS</u>
4.2.1	CASE A: SHEAR-OFF THE ANCHORS OF VERTICAL TENDONS
4.2.2	CASE B: SHEAR-OFF THE ANCHORS OF DOME TENDONS
4.2.3	CASE C: SHEARING-OFF THE HOOP TENDONS
4.3	<u>SPALLING DUE TO AIRCRAFT IMPACT ON THE OUTSIDE WALLS</u>
4.4	<u>IMPACT EFFECTS ON EQUIPMENT AND COMPONENTS</u>
4.5	<u>REFERENCES</u>

# TMI-1 UFSAR

## LIST OF TABLES

<u>TABLE</u>	<u>TITLE</u>
5A-1	Time Variable $t_n$
5A-2	Dynamic Load Factors (DLF)
5A-3	Kinetic Energy of The Dome
5A-4	Upper Bound Displacements
5A-5	Comparison of The Stress Resultants for Prestress Loadings
5A-6	Reactor Load (R) Calculations Case 1: With Wings and Engines Detached
5A-7	Reactor Load (R) Calculations Case 2: With Wings and Engines Attached

## TMI-1 UFSAR

### LIST OF FIGURES

<u>FIGURE</u>	<u>TITLE</u>
5A-1	Total Reaction Vs Time Curve
5A-2	Load Time Curve For 720 Aircraft At 200 Knots
5A-3	Maximum Dynamic Load Factor Vs Period or Frequency Of A One-Degree-Freedom System Under the Impact of Boeing 720
5A-4	Spherical Cap Under A Ring Load
5A-5	Spacial And Time Distribution of Load On Shell
5A-6	Grid For Dynamic Finite-Element Analysis of Aircraft Impingement on Dome
5A-7	Effect of Aircraft Impingement On Dome of Containment Structure - Constant Deceleration
5A-8	Deflections and Stresses For Aircraft Impingement for Time = 0.16 Seconds – Constant Deceleration
5A-9	Velocity Diagram For 720 Aircraft at 200 Knots Impact Speed with Wings and Engines Detached
5A-10	Velocity Diagram For 720 Aircraft at 200 Knots Impact Speed with Wings and Engines Attached
5A-11	720 Aircraft Mass Distribution
5A-12	Boeing - 720 Fuselage Buckling (Crushing) Load
5A-13	Time Variation of Shell Vertical Displacements with Wings and Engines Detached
5A-14	Time Variation of Shell Vertical Displacement with Wings and Engines Attached
5A-15	Time Variation of Shell Surface Stresses Aircraft with Wings and Engines Detached
5A-16	Time Variation of Shell Surface Stresses Aircraft with Wings and Engines Attached
5A-17	Pressure Distribution For Aircraft Impact
5A-18	Aircraft Impact At Girder to Dome Transition
5A-19	Aircraft Impact At Spring Line
5A-20	Radial Deflection Impact At Spring Line

## TMI-1 UFSAR

### LIST OF FIGURES (cont'd)

<u>FIGURE</u>	<u>TITLE</u>
5A-21	Aircraft Impact At Grade
5A-22	Rectangular Finite-Element
5A-23	For The Roof Slab Heat Exchanger Vault Moment Diagram
5A-24	DELETED
5A-25	DELETED
5A-26	Critical Aircraft Impact-Direction 1
5A-27	Concrete Cover to Protect Against Aircraft Impact
5A-28	Detail of Anchor Block
5A-29	Prestress Stresses After Nine Tendons Fail
5A-30	Critical Aircraft Impact-Directions 2 and 3
5A-31	Equal Spacing of Roof Tendons
5A-32	Dome Tendons
5A-33	Minimum Spacing of Hoop Tendons
5A-34	Comparison of Prestress Loading
5A-35	Reaction Load and Fuselage Decel. (with Wings and Engines Detached)
5A-36	Reaction Load and Fuselage Decel. (with Wings and Engines Attached)
5A-37	Hoop and Meridional Stresses at 36 Inches from the Edge of the Loaded Area
5A-38	Average Shear Stress in the Dome at time + = 0.20 seconds. Wing and Engines Remain Attached to Fuselage
5A-39	Average Shear Stress in the Dome at time + = 0.20 seconds. Wing and Engines Remain Detached to Fuselage
5A-40	FEM Model - Radial Stresses Due to Prestress and Aircraft Impact
5A-41	Radial Stresses Due to Prestress and Aircraft Impact
5A-42	Zones in Compression or Tension Due to Prestress or Aircraft Impact