

## CONTENTS

	Page
Preface	1
Summary	2
1. Introduction	3
1.1 Objective of the report	3
1.2 Gases and liquids with which the report is concerned	3
1.3 Subdivision of the report	5
1.4 Limitations of the report	6
2. Aspects of 'Unpressurized cooled storage'	8
2.1 Introduction	8
2.2 Storage systems	9
2.3 Possible problems	11
2.4 Undesirable consequences	14
2.5 Review of possible problems	18
3. Properties of concrete and concrete structures	19
3.1 Concrete	19
3.2 Reinforcing steel, prestressing steel, anchorages	23
3.3 Reinforced concrete	28
3.4 Prestressed concrete	29
3.5 Fibre-reinforced concrete	30
3.6 Impact loads, hits, etc.	31
3.7 Axial compressive and tensile impact loads	33
3.8 Temperature variations	33
3.9 Choice between reinforced concrete and prestressed concrete	36
3.10 Insulating materials	40
4. Storage systems and forms of construction in concrete	42
4.1 General	42
4.2 Double-walled steel tank, with insulation between inner and outer tank (SIS), and Single-walled steel tank, with insulation on the outside (IS)	42
4.3 Double-walled steel tank, with insulation between inner and outer tank, and surrounded by a concrete safety wall (C-SIS)	44
4.4 Single-walled steel tank, insulated on the outside, and surrounded by a concrete Safety wall (C-IS)	47
4.5 Single-walled steel tank, surrounded by a concrete safety wall which is insulated on the inside (C-IS)	48
4.6 Double-walled tank, with steel inner tank and concrete outer tank, and insulation between them (CIS)	50
4.7 Double-walled tank, with steel inner tank and concrete outer tank, and insulation between inner and outer tank ( $C_LIC_L$ )	52
4.8 Single-walled concrete tank, insulated on the outside ( $SIC_L$ )	53
4.9 Single-walled concrete tank, insulated on the inside (CIL)	54
4.10 Single-walled concrete tank, insulated on the inside, and surrounded by a concrete Safety wall (C-CIL)	57
4.11 Underground and /or earth-banked storage tanks	58
4.12 Tank standing free in a separate pit	61
4.13 Concrete roof structure	62
4.14 The optimum design	63

5.	Loads to be adopted in the design calculation	65
5.1	Design criteria	65
5.2	Ordinary loads (in normal use)	65
5.3	Special loads due to 'events of internal origin'	67
5.4	Special loads due to 'events of external origin'	68
5.5	Load combinations and load factors	69
5.6	Requirements applicable to concrete storage tanks	70
5.7	Requirements applicable to concrete safety walls	71
5.8	Test loads	72
5.9	Summary	73
6.	Structural arrangements and details	75
6.1	Foundation structures for concrete tanks	75
6.2	Wall-to-base connections	77
6.3	Wall structures	83
6.4	Roof structures and wall-to-roof connections	85
6.5	Functions of coatings and insulating layers attached to concrete structures	87
7.	Guidelines for technical operating requirements	91
7.1	Inspection and checks when the structure is in service	91
7.2	Commissioning and taking out of service	93
7.3	Operational requirements	94
8.	Constructional aspects and actual structures	95
8.1	Constructional and prestressing techniques	95
8.2	Review of projects executed	97
8.3	Particulars of some projects executed	101
9.	Concluding remarks	103
10.	References	105