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LIFERAFT SERVICE INTERVAL EXTENSION

Prepared for

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

by

MIL Systems
(DAVIE INDUSTRIES)
22 George-D.-Davie
Levis, Quebec
G8V 6N7

September 2003

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This report reflects the views of the authors and not necessarily those of the Transportation Development Centre of Transport Canada.

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Since some of the accepted measures in the industry are imperial, metric measures are not always used in this report.

PROJECT TEAM

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16. Abstract

Current international regulations require that inflatable liferafts must be inspected annually, while national regulations require inspections every two years for seasonally operated vessels and annually for all others. This annual inspection frequency is costly and inconvenient to ship owners; both of these aspects would be reduced if the time interval between service inspections were increased.

This report investigates the life saving reliability of liferafts with respect to the age of the liferaft by examining historical inspection data, field trial data and accelerated ageing tests on liferaft construction materials. The findings of this report support the extension of the liferaft service interval from one to four years. The report also recommends liferaft retirement, after 16 years in service or alternatively incrementally refering back to annual inspections for in-service liferafts.

The decreased inspection frequency will lessen the opportunity for damage to liferafts associated with the actual inspection process, reduce costs for the ship owner and thereby encourage ship operators to comply with the inspection regulations.

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16. Résumé

Selon la réglementation internationale actuelle, les radeaux de survie installés à bord des navires doivent être inspectés tous les ans. La réglementation nationale, quant à elle, exige, d'une part, que les radeaux de survie des navires exploités de façon saisonnière soient inspectés aux deux ans et, d'autre part, que les radeaux de survie des autres types de navires soient inspectés chaque année. Cette inspection annuelle est à la fois coûteuse et compliquée pour les propriétaires de navires, situation qui pourrait être facilement corrigée en augmentant l'intervalle entre les inspections.

Le présent rapport vise à déterminer la fiabilité des radeaux de survie en fonction de leur âge en étudiant les données historiques d'inspection, en procédant à des essais sur le terrain et en soumettant les matériaux de construction des radeaux à des essais de vieillissement accéléré. Les résultats de ce rapport appuient la décision d'accroître l'intervalle d'inspection des radeaux de survie pour la faire passer d'un an à quatre ans. Dans sa conclusion, le rapport recommande notamment de retirer les radeaux de plus de 16 ans et, dans le cas où ces derniers resteraient en service, de revenir graduellement à un mode d'inspection annuel.

Cette fréquence moindre d'inspection contribuera à réduire le risque de dommages aux radeaux associé au processus d'inspection, à réduire les coûts imposés aux propriétaires de navires et, ainsi, à encourager les exploitants de navires à se conformer au programme d'inspection.

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EXECUTIVE SUMMARY

Current international and national regulations require inflatable SOLAS liferafts to be inspected annually. Allowance has been granted in the national regulations of a service inspection of 24 months for seasonally operated vessels and 30 months for liferafts designed specifically for extended service.

The objective of this project is to investigate the effects of increasing the time interval between service inspections without compromising the safety and reliability of the liferaft. In addition, the increase in the inspection interval will benefit the ship owner by dispensing with the cost and inconvenience associated with annual inspections.

The results of the study are listed below:

- Historical inspection statistics indicate that the probability of a liferaft being condemned is ~1% below 4 years of age, ~10% between 4 and 16 years and increases rapidly thereafter. The statistics also show that the probability of a critical problem occurring is minimal below 4 years and increases rapidly to a maximum at 16 years, with an average age for liferafts with critical problems of 13.5 years.

- Data loggers, used to record environmental conditions to which liferafts in the field are subjected, show that liferafts are typically (approximately 80% of the time) exposed to temperatures between $0^{o}C$ and $20^{o}C$ and to relative humidity of 70-90%.

- Depot inspections carried out on field-tested liferafts less than 4 years of age revealed no problems after the liferafts were tested. The tests performed on the material showed that the mechanical properties were consistent with a liferaft of at least 4 years, with no significant degradation over the 4-year period.

- Three liferaft materials, butyl, polyurethane and natural rubber were subjected to accelerating ageing and then tested in accordance with TP-1324. With the exception of rubber, the liferaft materials do not start to fail TP-1324 until material is at least 12 years of age and in most instances not until material is over 15 years of age. Rubber fails TP-1324 mechanical properties e.g. breaking strength and elongation after 10 years and does not meet the requirement for porosity at 1 cycle of ageing (5 years) and even for no ageing (0 year).

- It was noted that all materials tested had porosity problems resulting from flex cracking. However, this could be anomaly in TP-1324 requirements rather than a problem inherent to the materials.

These results provide guidance for a suggested revision to the service interval schedule as indicated in the table below:

Revised Liferaft Inspection Interval Schedule

PROBABILITY CONDEMNED	AGE (YEARS)	SERVICE INTERVAL
< 1%	0 to 4	4 years
< 10%	4 to 16	2 years
> 10%	16 and up	1 year

Redefining the inspection interval schedule would reduce the number of required inspections. This would benefit the industry in a number of ways. It would reduce the cost and inconvenience to shipowners, which would in turn increase the adherence to the regulations. It would also minimize shipping and repacking, thereby reducing opportunities for the liferafts to be damaged

during this process. Marine safety would, therefore, be increased in two ways: liferafts would be less likely to be damaged through shipping and repacking, and more shipowners (especially small operators) would comply with the regulations and carry liferafts.

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1.0 INTRODUCTION

Current international and national regulations require inflatable SOLAS liferafts to be inspected annually. Allowance has been granted in the national regulations of a service inspection of 24 months for seasonally operated vessels and 30 months for liferafts designed specifically for extended service.

The objective of this project was to investigate the effects of increasing the time interval between service inspections without compromising the safety and reliability of the liferaft. This expense and inconvenience could be reduced if the time interval between service inspections were increased (i.e. biennial, triennial inspections). However, before any regulatory change can be made to extend the interval between service inspections, it must be shown that such an action would not result in a detrimental impact on the safety and reliability of liferafts. These investigations are intended to provide regulators with a sound scientific rationale on which to base decisions regarding the extension of the liferaft service interval. The work done in this study includes:

- A review of inspection forms from liferaft service depots in order to understand what problems and degree of degradation is typically found during annual inspections.

- Field-testing and recording of environmental parameters to determine the conditions to which liferafts are subjected.

- Depot inspections carried out on field-tested liferafts less than 4 years of age revealed no problems after the liferafts were tested. The tests performed on the material showed that the mechanical properties were consistent with a liferaft of at least 4 years, with no significant degradation over the 4-year period

- Deport inspection and testing of deployed test liferafts to determine the material properties after extended periods of service.

- Accelerated aging tests of liferaft materials under controlled laboratory conditions to assess the degradation of material properties over time.

This report describes the investigations carried out and the results obtained. Conclusions and recommendations are based on the results obtained.

2.0 BACKGROUND

This section provides some general background information to the project. The intent is to briefly describe an inflatable liferaft, the type of materials commonly used in their manufacture, the causes of liferaft degradation and the regulatory regime. This section ends with a brief discussion of what is meant by the term life saving reliability.

2.1 THE INFLATABLE LIFERAFT

Inflatable liferafts can vary widely in design details and materials used; however, fundamentally they are all similar. Figure 2.1 below shows a simplified drawing of a typical liferaft.

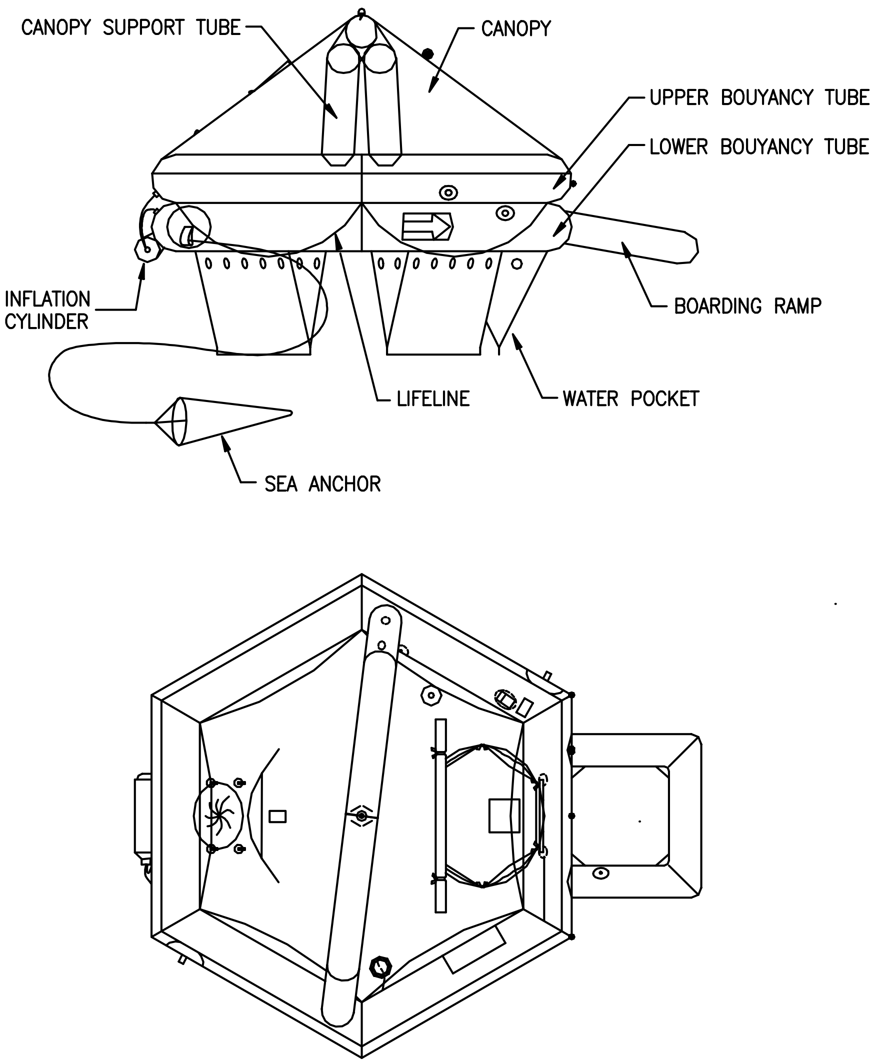

Figure 2.1 Simplified Liferaft Drawing

A liferaft is a system comprised of a number of distinct components, as described in Table 2.1 below:

Table 2.1 Liferaft Components

COMPONENT	DESCRIPTION
Buoyancy Chambers / Hull	A system of buoyancy tubes (usually an upper and lower tube) keep the liferaft afloat. Designed for redundancy, the hull consists of two independent buoyancy tubes, each with sufficient buoyancy to keep the liferaft afloat; a leak in one tube will not draw air from the other. In the past these tubes were made of cotton-backed rubberized material which was susceptible to mildew and rotting. Modern liferafts are constructed of synthetic materials that are highly resistant to rotting. Of particular interest in the hull design is the means by which panels are joined. Old technology uses adhesives, while newer technology uses heat sealing or Radio-Frequency (RF) welding (panels are fused together forming a bond at the molecular level).
Canopy	The canopy covers the hull to protect occupants against flooding and the environment. The canopy is brightly coloured to give a high degree of visibility to rescuers. The material used for canopy construction varies between manufacturers.
Inflation Cylinder	The inflation cylinder, typically steel or Kevlar-wrapped aluminum, houses compressed gas, which inflates the liferaft. Various gases are used, though a mixture of carbon dioxide and nitrogen is the most common. Currently, regulations require that the inflation cylinder must be checked every year to ensure functionality. Every 3 to 5 years, the cylinder undergoes hydrostatic testing to ensure the cylinder itself is not damaged. The cylinder is packed within the canister; so the canister must be opened to check the cylinder.
Canister & Seal	Liferafts are usually stored in fiberglass canisters. The canister is typically cylindrical in cross section to facilitate rolling. The cylinder is formed by two halves (semicircular cross section), which are sealed to keep out water. Rough handling of the canister can create hairline cracks in the fiberglass shell. These cracks may admit considerable water into the canister due to environmental conditions (rain, fog, snow etc.) and washings from waves. To address these problems, drainage holes are usually located in the bottom of the canister; the canister is thus not airtight or watertight.
Survival Pack	The liferaft canister also contains a survival pack. This may contain: flares, a radio, an emergency positioning device, food, a flashlight, an air pump and a patching kit. Certain items in the survival pack are replaced (i.e. flashlight batteries) during servicing.

2.2 LIFERAFT MATERIALS

The fundamental required attributes of a liferaft are floatation, protection from the elements and ease of location (Talbot Committee Recommendations, 1946). These attributes require different functions from buoyancy materials and canopy materials, implying that different material properties are expected from the compound materials employed for each function. As liferaft materials are composite fabrics, consisting of a textile strength membrane and a suitably compounded polymer to enhance the properties of the textile (and in the case of buoyancy materials, provide a protective gas holding layer) their material properties differ based on the textiles and polymers used in liferaft manufacture and on the manufacturing process. Table 2.2 outlines the material requirements, while Tables 2.3 and 2.4 demonstrate the range of material properties, Table 2.5 presents the current for the forming processes of material.

Table 2.2 Liferaft Material Requirements

	MATERIAL	REQUIREMENTS
Buoyancy Chambers	• Natural Rubber/Cotton • Natural Rubber/Nylon • Polychloroprene/Nylon Combinations • Two Ply Butyl • Thermoplastic Polyurethane/Nylon	• Good gas holding capabilities • Highly abrasion resistant • Flexible over a wide temperature range • Good tear resistance and low tear propagation • High strength to weight ratio • Resistant to ozone, UV, oils, trace metals and weathering • Easy for liferaft manufacturers to fabricate • Good ageing properties
Canopy	• Natural Rubber • Polychloroprene • Butyl • Polyurethane • EPDM • Silicone/Acrylics • Hypalon	• High visibility (fluorescent or bright orange) • No tainting of rain water collected via the canopy • High tear strength • Degradation resistance to trace metals, oils or other contaminants • Good ageing and weather resistant properties • Low weight and easily packed

Table 2.3 Liferaft Material Properties (I)

Property	Units/Method	Polyamide	Polyester	Tri-Acetate	Mod-Acrylic	CF Viscose	Glass	Kevlar Polyaramid
Breaking Strength (dry)	Tenacity N/TEX	Excellent 0.66	Excellent 0.56	Poor 0.12	Good 0.34	Fair 0.42	Good 0.40	Exceptional 1.90
Breaking Strength (wet)	Tenacity N/TEX	Excellent 0.57	Excellent 0.56	Poor 0.10	Good 0.32	Poor 0.32	0.28	Exceptional 1.90
Ease of Bonding	Adhesion	Good	Fair	Good	Good	Good	Fair	Fair
Abrasion Resistance	Stoll Universal Wear Tester	Good 100	Good 77	Poor 5	Good 40	Poor 9	Poor –	Excellent –
Flammability	Limiting Oxygen Index Values (%)	Fair 21	Fair 21	Poor 18.4	Excellent 29	Poor 19	Excellent –	Excellent 29
Flexibility	Scale 1-10	Excellent 9	Excellent 9	Fair 4-5	Good 6-7	Good 6	Poor 1	Fair/Poor 3
Ultra-Violet Resistance	Scale 1-10	Fair 5	Good 7	Fair 4	Excellent 8-9	Fair 4-5	Excellent 9-10	Poor 3

Source: Yorke-Robinson, A. (Greengate Polymer Coatings Ltd.), "Polymer Coated Fabrics for use in inflatable liferafts", International Conference on Marine Survival Craft – Liferafts, Lifeboats, Survival Systems, Royal Institute of Naval Architects (RINA), November 1983.

Table 2.4 Liferaft Material Properties (II)

Property	Units/Method	Natural	Butyl	Poly-Chloroprene	EPDM	Hypalon	Poly-Butadiene	Poly-Urethane	Nitrile/PVC	SBR	Chlorohydrin (Copolymer)
Permeability	Carbon Dioxide $cc/mm/cm^2/secs/cmHg/x10^{10}$	1330	60	250	985	208	1380	65	200	1240	125
Adhesion to Nylon	[Kg/50mm] High Tenacity 235 DTEX, $85gm^2$ 17 x 17/cm	6	4.5	8	4.5	4.5	4	6	6	5	4.5
Abrasion Resistance	Martindale Abrader	3	2	3/4	3	4	2	4	4	3	3
Low Temperature	Glass Transition Point [^{O}C]	-75	-79	-49	-60	-28	-85	-50	-24	-60	-53
High Temperature	Recommended Maximum [^{O}C]	60	120	100	140	120	60	70	102	60	125
Ozone Resistance	25 pphmO_3 25^{o}C	2	3	3	4	4	1	4	3/4	2	4
Oil Resistance	DTI Clause 25.9	2	2	4	3	4	2	4	4	2	4
Flame Resistance	DIN 53907	1	1	3	1	3	1	1	3	1	2/3
Shaded Cells Indicate Relative Rating: 1 = POOR, 2 = FAIR, 3 = GOOD, 4 = EXCELLENT											
Source: Yorke-Robinson, A. (Greengate Polymer Coatings Ltd.), “Polymer Coated Fabrics for use in inflatable liferafts”, International Conference on Marine Survival Craft – Liferafts, Lifeboats, Survival Systems, Royal Institute of Naval Architects (RINA), November 1983.											

Table 2.5 Current Material Forming Processes

PROCESS	DESCRIPTION
Impregnation/Dipping	Polymer is dissolved in solvent (i.e. Toluene, Acetone, Methyethylketone) to form a dilute solution; textile is passed through solution (dipped) and then dried to remove the solvent.
Spreading	Polymer is dissolved in solvent to form a "dough". Dough is spread on textile by means of doctor blade and passed through a heated oven to remove solvent.
Calendering	Heat and mechanical energy is applied to polymer to convert it to a soft pliable film, film is transferred to pre-treated textile using heavy rollers.
Laminating	Pre-formed polymer film is applied to textile using adhesive, heat and pressure.
Combination	The four processes noted above may be used not only as discrete processes but also in combination to build up a composite material.

2.3 LIFERAFT DEGRADATION

A number of factors contribute to the degradation of the liferaft system. Each of these factors, summarized in Table 2.6, degrades liferaft system components in different ways:

Table 2.6 Liferaft Degradation Factors

DEGRADATION FACTOR	DESCRIPTION
Mechanical Damage	Rough handling of the canister can lead to cracking of the canister. Inflation and re-packing of the liferaft can lead to mechanical damage of the liferaft. Weak spots in the material can be created due to folding and this can lead to possible tearing.
Water & Humidity	Exposure of the liferaft to water and humidity can result in mildewing and rotting of the liferaft material and adhesives used in construction.
Salt	Exposure of the liferaft to saltwater may lead to accelerated mildewing and rotting. Chemical degradation of the liferaft material is possible when in contact with a saline solution. Crystallized salt may accelerate abrasion due to vibration.
Temperature & Temperature Cycling	Temperature cycling from the extreme cold of winter to extreme heat of summer may adversely affect the synthetic materials used in liferaft construction. In extreme cold, the liferaft material can become stiff and brittle, sudden mechanical action such as inflation while in this state may lead to fracture. The reliability of inflation heads in extreme cold temperatures is also questionable.
Ultraviolet Radiation	Ultraviolet (UV) radiation may weaken liferaft canisters. The canister prevents UV penetration and thus exposure of the packed liferaft.
Vibration	Continuous vibration of the canister can cause the liferaft within to rub back and forth upon itself and against the canister causing abrasion damage.
Ice & Freezing	Damage to the liferaft canister is possible due to icing and the crew's actions in de-icing (beating ice off the canister). Water trapped inside the canister will expand when frozen possibly leading to mechanical damage of the liferaft.

Published information on liferaft degradation is extremely limited. However, a past report by Melville Shipping Ltd [1] provides some relevant information. A questionnaire (see Appendix B) was sent to a number of liferaft manufacturers: Beaufort Air-Sea Equipment, Dunlop Limited (UK), Tul Safety Equipment Ltd. and Viking (Denmark). A key question asked was *"What, in your opinion, are the main causes of deterioration other than water?"* Responses included:

- Air
- Heat
- Cold
- Atalytic agents
- Fungus
- Abrasion
- Salt water wicking
- Abuse by owners
- Poor servicing

A second questionnaire was sent to a number of Canadian service depots; Air-Sea Equipment (NS), Atlantic Bridge (NS), G & A Bourque (QC), Clipper (QC), BC Ferries (BC), Green Shore Marine (PEI), IMP (NS), IMP (NF.), Inuvik Liferaft Depot (NWT), J. Lecke (QC), and C.W. Lucas (BC). The results (presented in the Appendix B) show canister damage during shipping between service depot and the ship to be a problem, while very few problems with fabric degradation, inflation system or emergency pack were reported. It should also be noted that fabric problems were generally associated with older cotton-based liferafts; these are now banned.

The problems presented to ship owners by the annual servicing requirement, along with the minimal material and component problems noted during inspection provides a strong impetus for investigating the possibility of extending the service interval. A recent study by MGI International Marine Safety Solutions Inc. [2] documents the development of a SOLAS liferaft that would require servicing every two years or more. This report presents in detail the design of a liferaft suitable for extended service intervals. However, limited research and discussion is presented regarding the life expectancy or degradation of liferaft materials and components in the field.

2.4 REGULATIONS

2.4.1 SOLAS

Internationally, minimum standards and regulations regarding lifesaving appliances are governed by the International Maritime Organization (IMO). IMO's International Convention for the Safety of Life at Sea, 1974, and its Protocol of 1978: articles, annex and certificates and subsequent amendments are collectively referred to as SOLAS [3]. Chapter III of SOLAS covers life-saving appliances and arrangements. Regulation 19 (8) of Chapter III defines the service interval for inflatable liferafts on passenger and cargo ships:

Regulation 19

8 Servicing of inflatable liferafts, inflatable life jackets and inflated rescue boats

8.1 Every inflatable liferaft and inflatable lifejacket shall be serviced:

1) at intervals not exceeding 12 months. However, in cases where it appears proper and reasonable, the Administration may extend this period to 17 months;
2) at an approved servicing station that is competent to service them, maintains proper servicing facilities and uses only properly trained personnel.

2.4.2 CANADA SHIPPING ACT

The Canada Shipping Act (CSA) and its related regulations, standards and guidelines form the basis of Canada's marine regulatory regime and reflect Canada's ratification of IMO regulations. Under the CSA, the *Life Saving Equipment Regulations* (CSA-32), Schedule IV [2], define the service interval for liferafts:

Schedule IV – Servicing of Inflatable Survival Equipment

2.

(1) Inflatable survival equipment shall be serviced annually in accordance with the recommendations of the manufacturer of the equipment.

(1.1) Despite subsection (1), the interval between servicing may be two years if

(a) the ship on which the inflatable survival equipment is carried
   (i) is not a Safety Convention ship, and
   (ii) operates for less than seven months per year;

(b) fewer than 15 years have elapsed since the inflatable survival equipment was manufactured;

(c) the validity period of the most recent hydrostatic test of the gas cylinders of the inflatable survival equipment will not expire before the next servicing;

(d) the inflatable survival equipment is stored in a dry location during the months in which the ship is not in operation.

(Section (1) was amended on the March 15, 2002).

(2) All of the tests and procedures recommended by the manufacturer of inflatable survival equipment shall be carried out each time the equipment is serviced.

3.

The opening, testing, repairing and repacking of inflatable survival equipment shall be carried out in accordance with the recommendations of the manufacturer of the equipment, and shall include an inspection for signs of:

(a) damage to the equipment container; or
(b) dampness in the interior of the equipment container and the equipment.

4.

(1) A gas inflation test shall be carried out every five years.
(2) When a gas inflation test is being carried out, special attention shall be paid to the effectiveness of the pressure relief valves.
(3) After gas inflation has been initiated, sufficient time shall be allowed to enable the pressure in the buoyancy compartments of the inflatable survival equipment to become stabilized and any solid particles of carbon dioxide to evaporate.
(4) After the time referred to in subsection (3) has elapsed, the buoyancy compartments shall, if necessary, be topped up with air and the inflatable survival equipment subjected to a pressure-holding test over a period of not less than one hour, during which time the pressure drop shall not exceed 5 per cent of the working pressure.

5.

(1) Inflatable survival equipment shall be subjected to the necessary additional pressure test set out in subsection (2) or any other similar test recommended by the manufacturer
  (a) during the first servicing of the equipment;
  (b) whenever a visual inspection indicates that a necessary additional pressure test should be carried out to ensure the safety and reliability of the equipment; and
  (c) at each servicing of the equipment after its tenth year in service.
(2) A necessary additional pressure test shall be conducted by
  (a) plugging the pressure relief valves;
  (b) gradually raising the pressure to the lesser of
    (i) twice the working pressure, and
    (ii) a pressure that is sufficient to impose a tensile load on the compartment fabric of at least 20 per cent of the minimum tensile strength recommended by the manufacturer;
  (c) after five minutes, checking that there is no significant pressure drop, seam slippage, cracking or other defects;
  (d) if there is no audible cracking in the buoyancy compartments, reducing the pressure in all of the buoyancy compartments simultaneously by removing the plugs from the pressure relief valves; and
  (e) after sufficient time has elapsed for the equipment to regain fabric tension at the working pressure, subjecting the equipment to a pressure-holding test over a period of not less than one hour, during which time the pressure drop shall not exceed 5 per cent of the working pressure.
(3) If, at any time during the necessary additional pressure test, there is audible cracking in the buoyancy compartments, the equipment shall be withdrawn from service.

6.

(1) Where a gas inflation test or a necessary additional pressure test is not required as part of a particular servicing, inflatable survival equipment shall be removed from its container and from any fitted retaining straps and subjected to a working pressure test.
(2) A working pressure test shall be conducted by
  (a) inflating the inflatable survival equipment with dry compressed air to the working pressure; and
  (b) subjecting the inflatable survival equipment to a pressure-holding test over a period of not less than one hour, during which time the pressure drop shall not exceed 5 per cent of the working pressure.
(3) If, during a working pressure test, the ambient temperature varies by more than 3°C, the results shall be disregarded and the test repeated.

7.

The seams of inflatable survival equipment shall be inspected and tested during the first servicing of the equipment and each servicing of the equipment after its tenth year in service, by:

(a) inspecting both sides of the bottom seams of a life raft;
(b) inspecting the seams of a marine evacuation system with the system fully deployed;
(c) inspecting the seams between the floor and the buoyancy compartments of inflatable survival equipment for slippage or edge lifting; and
(d) after completion of each inspection referred to in paragraph (c), supporting the buoyancy chamber at a suitable height above the service floor, having a person weighing not less than 75 kg walk or crawl around the entire circumference of the floor of the equipment and inspecting the floor seams a second time.

In Canada, standards relating to liferafts, and materials of construction, are published by Transport Canada. The *Standards for Life Rafts and Inflatable Rescue Platforms* (TP-7321) [4] identify various material properties and tests required of liferaft components. The *Material Specification for Coated Fabrics Used in the Manufacture of Inflatable Liferafts* (TP-1324) [5] defines specifications for materials used in liferaft manufacturing and materials testing procedures.

2.5 ANNUAL INSPECTION PROBLEMS

As noted in the previous section, Canadian and international regulations dictate that inflatable liferafts must be inspected annually. This annual inspection requirement creates two primary problems of concern:

1. Inconvenience and expense to ship operators: annually, each liferaft must be physically removed from its vessel and transported to a land-based testing/inspection facility. Over the lifetime of the liferaft, inspection costs can exceed the purchase price of the liferaft. As a result the process is either very costly to shipowners, or small shipowners simply do not comply with the service regulations.

2. Degradation of the liferaft: The process of inspection itself may contribute to the degradation of the liferaft; re-packing of liferafts can introduce new folds, material stress and possible abrasion damage to the liferaft. In addition, handling and shipping of liferaft canisters to and from the testing/inspection facility can lead to damage of the liferaft canister.

Both these problems may be alleviated by extending the service interval between inspections. For example, making the inspection interval biennial instead of annual would halve the inconvenience and expense to ship operators. However, any motion to extend the service interval must be carried out with due diligence in assessing what, if any, affect this would have on the lifesaving reliability of liferafts.

2.6 LIFESAVING RELIABILITY

Any consideration of extending the service interval between liferaft inspections is contingent on the knowledge that in doing so, the lifesaving reliability of the liferaft system will not be compromised. When using the term “lifesaving reliability” we are referring to the ability of the liferaft to perform its function acceptably.

As discussed in Section 2.1, the liferaft system includes:

- Buoyancy Chambers
- Canopy
- Inflation Cylinder
- Survival Pack
- Canister and Seal

Although the last three items on this list are essential components of the liferaft system, they were not considered during the investigations made during this project. Cost and time constraints restricted the current investigation to the buoyancy chambers and their durability over time. Issues regarding extending the service interval on the other items should definitely be subject to future research.

The objective of the investigations under this project is to determine whether the buoyancy chambers of a liferaft will perform their function over an extended service interval.

3.0 HISTORICAL INSPECTIONS

This section provides a review of standard liferaft inspection forms produced by the Dunlop Beaufort Canada (DBC) depot in Richmond, B.C. The intent of this review was to generate statistical data regarding problems encountered during inspections that required repair, the frequency of these problems, and their correlation to the age of the liferaft and the time since the last inspection.

A historical review of liferaft inspection forms over a number of years provides an indication of common problems and also indicates the age of the liferafts when these problems began to surface. This was deemed a useful component to the project as it provides information on a wide range of liferafts and material types.

3.1 RECORD KEEPING AND STATISTICS

The master database consists of 1332 liferaft inspection forms (records) and stores raw data from a standard service depot inspection form, including:

- Inspection Form Certificate #
- Service Date
- Date of Last Service
- Date of Liferaft Manufacture
- Comments; as noted on inspection form identifying work completed (i.e. canister repair, valise replacement, material repair etc.)

Before entry into the database, inspection forms undergo a screening process. Incomplete inspection forms (i.e. no last service data entered or date of manufacture unknown) were not included. In addition, a small number of inspection forms were omitted as they were deemed abnormal. For example, inspection forms for liferafts that had been operationally used were omitted due to the possibility of abnormal inspection intervals and/or damage; the intent of database analysis is to draw conclusions regarding liferafts in a normal inspection cycle.

From the raw data noted above, the following data is calculated/derived for each record:

- Liferaft Age
- Time Interval Since Last Inspection
- Identification of "Problems": Yes or No to each of 7 "problem" categories

The 'Comments' field of each record provides text regarding "problems", if any, associated with the liferaft inspected and notes work performed by the service depot. The type of "problems" noted may be categorized as shown in Table 3.1:

Table 3.1 Possible Liferaft Problems

PROBLEM	PROBLEM DESCRIPTION
Buoyancy Material Repair	Inspection form notes repairs made to buoyancy chamber, arch or ramp. Such repairs typically result from leakage testing. This problem is the primary cause for a liferaft being condemned; high porosity or adhesion problems render the liferaft un-economical to repair.
Canopy Material Repair	Inspection form notes repairs made to canopy material.
CO_2 System Repair	Inspection form notes repair to CO_2 system such as hose replacement or valve rebuild. Hydrostatic testing or bottle recharge was not considered a repair.
Canister Repair	Inspection form notes repairs made to the liferaft canister. Repairs typically involve patching of cracks (fiberglass). It is impossible to determine the cause of damage, however, the two primary suspects are (1) dropping or rolling canister while removing from the ship and shipping to the service depot for inspection (it is duly noted that this damage may well also occur during shipment back to and re-installation onboard ship), or (2) damage caused by canister loosely secured in its cradle and subject to ship motions (canister rattling in cradle).
Painter Replacement	Inspection form notes painter line replaced.
Valise Replaced	Inspection form notes valise replaced. This is a category noted in the database but is not deemed a 'repair'. The valise is not a component of the liferaft itself, but rather a means to facilitate packing and protecting the liferaft from internal chafing. Valise replacement is quite common during inspections involving inflation as the inflation breaks apart the valise by design.
Other Repair	Inspection form notes some other repairs other than those noted by other categories. This is a ‘catch-all’ or miscellaneous category to cover items such as repair to lights.

A single record may have more than one problem. For example, the inspection form associated with the record may indicate canister repair, valise replacement and a material repair.

Categorizsation is made to allow analysis regarding the frequency of various "problems". In particular, Buoyancy Material Repair and CO_2 System Repair are deemed "critical problems”. That is, these problems can adversely affect the lifesaving capability of the liferaft. This is subjective depending on the extent of the problem (i.e. a small leak in the buoyancy chamber material could be patched). However, simplified problem categorization and record by record identification (yes/no) of problems allows the database to be divided into various datasets:

- All database records (complete database)
- Only records for condemned liferafts
- All records except those for condemned liferafts (serviceable liferafts)
- Only records for serviceable liferafts with “critical” problems

These datasets permit general conclusions to be drawn from the statistics.

3.2 LIFERAFT INSPECTION DATABASE SYSTEM

To simplify obtaining and manipulating recent service inspection reports, a computer program called the Liferaft Inspection Database System (LIDS) was developed to store inspection forms in electronic format. Appendix E presents the User Guide for LIDS. The LIDS inspection form is based on that used by Dunlop Beaufort Canada (DBC) and includes all information required by Transport Canada. The LIDS program provides a number of advantages to both the liferaft service depot and to Transport Canada, specifically:

- An electronic database of liferafts and customers provides a useful management tool. LIDS can simplify form completion by eliminating repetitive data and can be used to report information such as; liferaft serial number and owners of liferafts overdue for service interval extension, number of liferafts due for a specific owner due for inspection within the next 6 months, etc.

- An electronic copy of the depot's database can be sent by e-mail to Transport Canada instead. Currently, service depots are required to submit paper copies of inspection forms to Transport Canada.

- The ability to merge new databases into the existing program database. If all Canadian depots use the LIDS program and e-mail databases periodically to Transport Canada then it becomes powerful tool. By maintaining a central database and merging the databases periodically sent by the service depots, a master database of all service inspections carried out in Canada is created. This can be used to identify the service history of any liferaft and to identify liferafts that are not adhering to regulatory requirements (1 year service interval).

4.0 FIELD TRIALS

This section describes the experimental deployment of liferafts on the West Coast, East Coast and Central Canada for various periods of time, and describes the function and operation of the devices used to record environmental conditions.

4.1 DATA LOGGERS

Data loggers were employed to record the environmental conditions to which liferafts are typically subjected. Data loggers were incorporated on a number of experimental liferafts, and were set up to continuously record data for the duration of liferaft deployment. Each liferaft canister was modified to include a bolted access port to allow the placement and removal of data logging equipment.

4.1.1 DATA COLLECTION

4.1.1.1 Temperature and Relative Humidity

The data loggers record time, internal box temperature (through an internal channel) external temperature and relative humidity (through external channels). The data loggers were configured to record the following data once per hour (a sampling rate of 1/3600 Hz):

- Time (log start time logged)
- Temperature internal to data recorder box
- Probe temperature (Channel 1 of 4 external)
- Probe relative humidity (Channel 2 of 4 external)

The data loggers are battery powered and operate unattended, recording data to internal memory. At one sample per hour, the data-logger's main battery can power data recording for about 393.6 days (1.08 years). Each data logger has 32k of onboard memory, and with the channel configuration given, allowed data storage for approximately 200 days. The main battery also charges a small internal memory battery, which keeps data stored in memory for about 5 years.

4.1.1.2 Ultra-Violet Radiation

Consideration was given to the degradation of liferaft fabric inside the canister due to ultra-violet (UV) radiation. A sample of canister material was sent to the National Research Council (NRC) in Ottawa for UV testing. These tests concluded that UV transmission through the canister was negligible [6]; therefore, no effort was made to record UV data.

4.1.1.3 Vibrations

Consideration was also given to the degradation of liferaft fabric inside the canister due to vibration induced by both normal hull borne vibration (rotating machinery) and ship motions in a seaway. A liferaft within a canister may be subjected to abrasions from material on material contact or material on canister contact. Monitoring vibration data, however, would have required the incorporation of an accelerometer package (X, Y and Z accelerations) into the data logger. This was an expensive proposition and it was deemed that project funds were better spent on additional data loggers. This decision was rationalized by considering that any acceleration data logged would be very vessel specific. Nevertheless, a single data logger (ShockLog) with built-in accelerometers was acquired and this was rotated among various project liferafts to sample vibration data.

4.1.2 CANISTER AND LOGGER DEPLOYMENT

Initially the data loggers were configured so that they would record data only until the memory was full. After the first data download for each data logger, the configuration was changed so that once the memory was full, new data would be written over the oldest data stored. This configuration change was made because there were often delays in gaining access to vessels to install a new data logger. The initial configuration resulted in data recording while the logger was awaiting installation onboard its host vessel. The time between logger removal from a canister and the time of downloading was much shorter than the time between a reset logger being shipped and installed. Thus, configuring the data loggers to write over the oldest recorded data once the memory was full typically provides a longer useable data set.

During the course of this project, 27 liferafts and inflatable platforms were deployed. These were hosted by four Canadian shipping companies: Seaspan International Ltd., Marine Atlantic, Oceanex (1997) Inc. and B.C. Ferries. Table 4.1 identifies each liferaft/platform, the host vessel and data logger installation.

Ideally, there would have been a data logger for each canister, but this was cost prohibitive. Working with the data loggers available, the ideal solution would have been to deploy the canisters in pairs. Each pair, one with a data logger and one without, would be hosted by a different vessel. However, this was not achievable due to difficulties in finding host vessels (vessel owners were not paid to host canisters) and the costs associated with installing canisters and exchanging data loggers over the course of the project.

At project initiation, an agreement was made between Transport Canada and Seaspan to have Seaspan host all 24 (initially only 24 canisters) on Seaspan's west coast tugs and barges. As the project progressed, there was a desire to have canisters on both coasts so that data obtained would be representative of operations throughout Canada. Deployment was made on the west coast (Seaspan and BC Ferries), east coast (Marine Atlantic) and central Canada.

Table 4.1 shows a major re-deployment on May 2000. At this time, arrangements were made with BC Ferries to host canisters on three of their vessels. This was done to increase the number of vessels and environmental conditions included in the project. Six canisters were re-deployed to BC Ferries vessels: four from the Atlantic Freighter (east coast) and two from Seaspan vessels (west coast). Two were taken from Seaspan as their host vessels were operating in Portland, which made access difficult. Four were taken from the Atlantic Freighter as this vessel was scheduled to spend significant time dockside.

The most difficult task associated with data logger swapping proved to be arranging vessel access at suitable times; that is, when the logger memory is close to full. Generally, logger swapping was left until memory was nearly full to limit the number of swaps made. The reasons were twofold: firstly to obtain data sets with long periods of continuous data, and secondly to reduce costs (agent fees in conducting data logger swapping).

It should be noted that canisters were located in positions convenient to the host vessel so as not to interfere with normal vessel operation. Generally, exposed decks subject to sea exposure were used. Liferafts that are a normal part of the ship's survival equipment are usually stored in sheltered locations. The canisters deployed for this project were generally in locations that would not be used for a standard ship's liferafts. This was deemed acceptable (and mostly without choice) as the project canisters would represent a 'worse case' example in terms of exposure.

Table 4.1 Experimental Liferaft Deployment

CANISTER	HOST VESSEL	LOGGER	REDEPLOYMENT
WEST COAST DEPLOYMENT (SEASPAN)			
8689-6FT	Seaspan Barge 240/250		
8696-6FT	Seaspan Barge 240/350		✔
8697-6FT	Seaspan Barge 240/250		
8669-10/15IBA	Seaspan Barge 240/250		
8438-10/15IBA	Seaspan Barge 251		
8439-10/15IBA	Seaspan Barge 251		✔
8706-6FT	Seaspan Monarch	✔	
8692-6FT	Seaspan Monarch	✔	
8440-10/15IBA	Seaspan Harvester	✔	
8442-10/15IBA	Seaspan Rigger	✔	
8439-10/15IBA	Seaspan Rigger		
8704-6FT	Haida Brave		*
8668-10/15IBA	Haida Monarch		*
9725-6FT	Haida Monarch		*
WEST COAST DEPLOYMENT (BC FERRIES)			
8705-6FT	Prince Rupert	✔	
8695-6FT	Prince Rupert		
8696-6FT	Spirit of British Columbia		
8443-10/15IBA	Spirit of British Columbia		
8442-10/15IBA	Quinitsa	✔	
8707-6FT	Quinitsa		
EAST COAST DEPLOYMENT (MARINE ATLANTIC)			
8688-6FT	Atlantic Freighter	✔	
8693-6FT	Atlantic Freighter	✔	
8695-6FT	Atlantic Freighter		✔
8698-6FT	Atlantic Freighter		
8705-6FT	Atlantic Freighter		✔
8707-6FT	Atlantic Freighter	✔	✔
8437-10/15IBA	Atlantic Freighter	✔	
8441-10/15IBA	Atlantic Freighter		
8443-10/15IBA	Atlantic Freighter	✔	✔
8444-10/15IBA	Atlantic Freighter		
8445-10/15IBA	Atlantic Freighter	✔	
8446-10/15IBA	Atlantic Freighter		
CENTRAL DEPLOYMENT (OCEANEX)			
7971-10/15IBA	Cicero	✔	
9721-6FT	Cicero		

Notes:
1) Canister Suffixes: – 6FT = liferaft, -10.15IBA = inflatable platform
2) * denotes liferaft that was lost at sea

4.2 EXPERIMENTAL LIFERAFT DEPLOYMENT

4.2.1 DEPOT INSPECTIONS

Periodically a project trial canister was returned to a liferaft service interval and subjected to a normal service inspection. A standard service inspection form was generated and any problems reported.

Regular inspection testing determined if liferafts that had been in the field for two, three or four years would pass a standard service interval inspection. It was recognized that the inflation system maintenance and replacement of pyrotechnics and rations are part of a normal inspection, however, of specific interest to this project was what work to the liferaft buoyancy chambers would be required to pass inspection. If results from inspections conducted show that no work was required to the hulls, then this could be used as evidence in support of extending the interval between inspections for the hulls.

4.2.2 MATERIAL TESTING

This project was primarily concerned with buoyancy materials, as these are critical to the lifesaving capability of a liferaft. Specifications for materials to be used in the construction of liferafts are outlined in Transport Canada's Ship Safety Publication TP-1324: "Material Specification for Coated Fabrics Used in the Manufacture of Inflatable Liferafts". TP-1324 defines material property requirements and test methods for both buoyancy and canopy materials to ensure the lifesaving reliability of a liferaft.

It may thus be concluded that if the material properties of a liferaft, regardless of the age of the liferaft, meet the material specifications defined by TP-1324, then the liferaft must be deemed 'acceptable' from a materials perspective. It is noted that there are other issues to be considered in addition to materials, most notably, cylinder maintenance, rations and emergency equipment such as flares.

Change to the lifesaving reliability of a liferaft over time (age of the liferaft) depends on how the liferaft material properties change with time. Figure 4.1 illustrates the theoretical question being addressed.

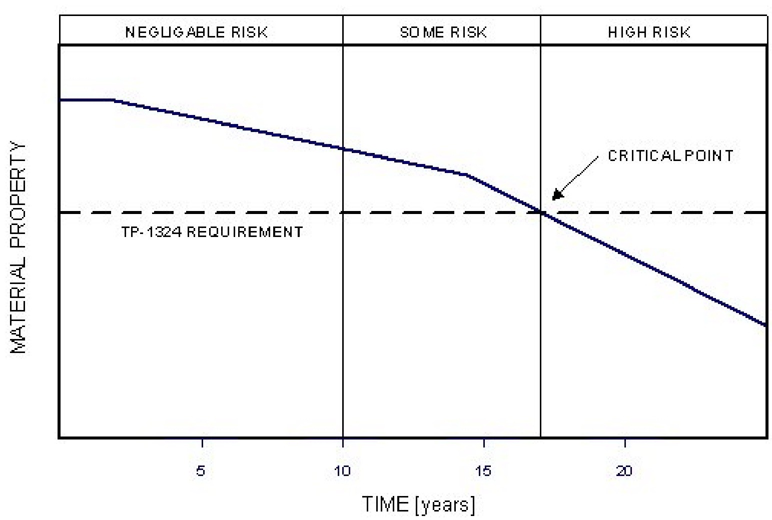

Figure 4.1 Lifesaving Reliability v. Time

By observing the change in material properties over time, it is possible to estimate when material properties would fail to meet the TP-1324 requirements (the critical point on Figure 4.1).

The Textile Technology Centre (TTC) in St. Hyacinthe, QC, was contracted to perform materials testing. Material samples taken from experimental liferafts deployed during the project were subjected to a sub-set of the tests defined by TP-1324. Samples were taken from experimental liferafts that had been in the field for a number of years. The intent was to establish the extent of material properties degradation occuring over time for in-service liferaft materials.

Due to cost limitations, it was decided to limit the materials properties tested to allow additional sample testing. The following material properties were tested:

[1] Weight
[2] Breaking Strength
[3] Elongation at Break
[4] Tear Strength
[5] Puncture Resistance
[7] Porosity
[8] Flex Cracking
[10] Oil Resistance

These tests will give first-hand results of liferaft material degradation due to environmental exposure for up to 4 years. However, for material performance over an extended time period, materials must be artificially aged and tested.

5.0 ACCELERATED MATERIAL TESTING

This section describes the procedure of accelerated ageing and materials testing. As with materials testing in Section 4.2.2, materials that meet the requirements defined in TP-1324 are deemed as suitable for the manufacture of liferafts by Transport Canada. It is therefore concluded that these requirements define the baseline material requirements to ensure the lifesaving reliability of a liferaft.

5.1 PURPOSE

Of specific interest to this project is the lifesaving reliability of a liferaft and how this changes with time (age of the liferaft). That is, how the liferaft material properties change with time. Figure 5.1 (repeated for clarity) illustrates the theoretical question being addressed. Material testing reported here will establish the shape of the material property curves and to define the "critical" points.

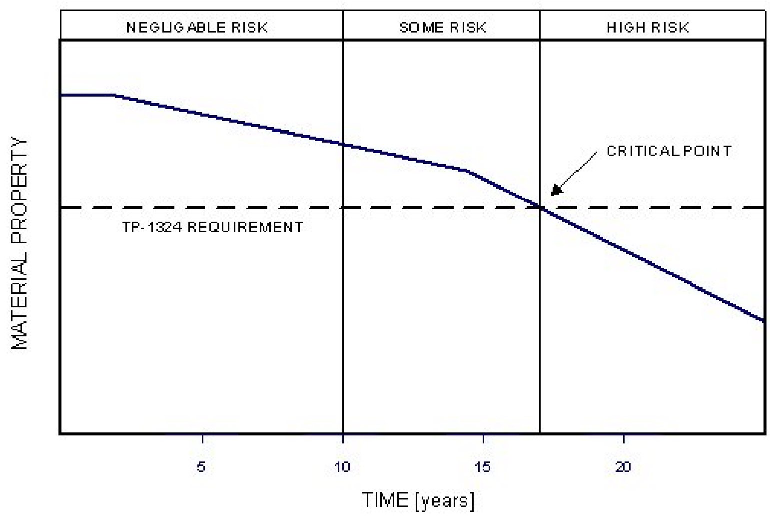

Figure 5.1 Lifesaving Reliability v. Time

5.2 TEST METHODOLOGY

Accelerated weathering tests were performed on three types of materials commonly used in the manufacture of liferaft buoyancy chambers: butyl, polyurethane and rubber. For each material type, a sub-set of the materials testing defined in the Transport Canada publication "Material Specification for Coated Fabrics Used in the Manufacture of Inflatable Liferafts" (TP-1324) was completed. This sub-set of tests was conducted for each sample four times as follows:

1. Artificial Age = 0 Years (Baseline testing of new material samples)
2. Artificial Age = 10 Years
3. Artificial Age = 15 Years
4. Artificial Age = 20 Years

Nine (9) samples of liferaft buoyancy material were subjected to accelerated ageing and material testing. Each sample consisted of four 1m x 1m squares of material. Three samples each of three different materials were tested: Butyl, Polyurethane, and a Rubber-based material. Test results for each material type are discussed in Sections 6.3 and 6.4.

Accelerated ageing involved a repetitive artificial ageing of material and subsequent testing in a four-cycle test process as indicated below:

For each sample, the accelerated ageing and material test process was as follows:

[A] 1/4 of sample (one of 1m x 1m pieces) was subjected to a sub-set of the tests defined by TP-1324 to define baseline (year = 0) material properties. TP-1324 tests performed on this sample included (TP-1324 section referenced in brackets):

- Weight (3.2.1)
- Breaking Strength (3.2.2)
- Elongation at Break (3.2.3)
- Tear Strength (3.2.4)
- Puncture Resistance (3.2.5)
- Porosity (3.2.7)
- Flex Cracking (3.2.8)
- Oil Resistance (3.2.10)

[B] The remaining 3/4 of the sample (three of 1m x 1m pieces) were subjected to two cycles of the five-year artificial ageing process. Each cycle of the artificial ageing process were as per TTC proposal using the ASTM D 5427-98 standard practice to simulate five years of natural ageing. These three material pieces had a simulated age of ten years.

[C] One 1m x 1m piece of the ten year artificially aged material were subjected to the TP-1324 sub-set of material tests as noted in [A] above plus the Low Temperature Flexing (TP-1324, 3.2.9) test. These results defined the year = 10 material properties.

[D] The remaining 1/2 of the sample (two of 1m x 1m pieces) were subjected to an additional five-year artificial ageing cycle. These two material pieces had a simulated age of 15 years.

[E] One 1m x 1m piece of the 15 year artificially aged material were subjected to the TP-1324 sub-set material tests as in [A] above. These results defined the year = 15 material properties.

[F] The remaining 1/4 of the sample (one of 1m x 1m pieces) were subject to a final five-year artificial ageing process. This material piece had a simulated age of 20 years.

[G] This last piece of sample material were subjected to the TP-1324 sub-set material tests as in [A] plus Low Temperature Flexing (TP-1324, 3.2.9). These results defined the year = 20 material properties.

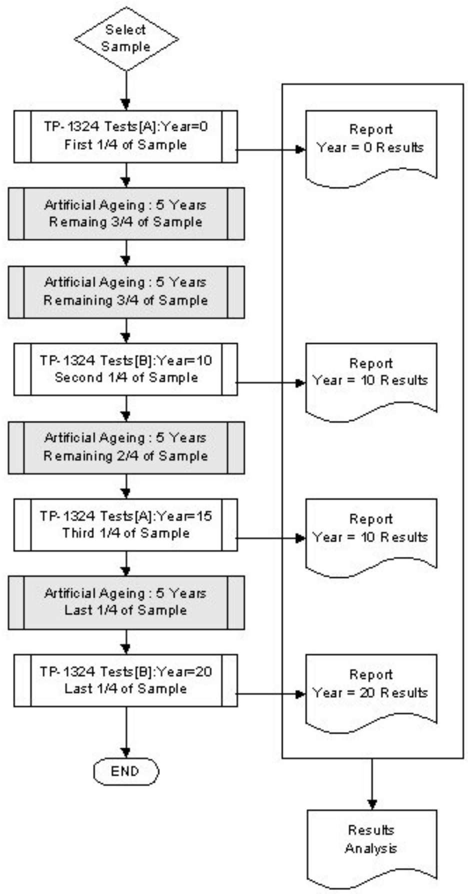

Figure 5.2 Accelerated Ageing Materials Testing Program

Table 5.1 below identifies the material properties test results obtained from each sample. The test process is shown schematically in Figure 5.2 above. TP-1324[A] noted in this figure indicates the sub-set of tests identified in [A], while TP-1324[B] indicates the same plus the Low Temperature Flexing (TP-1324, 3.2.9) test.

Table 5.1 Accelerated Ageing Materials Tests

MATERIAL TEST	TP-1324 REFERENCE	SIMULATED AGE [YEARS]			
		0	10	15	20
Weight	3.2.1	✔	✔	✔	✔
Breaking Strength	3.2.2	✔	✔	✔	✔
Elongation at Break	3.2.3	✔	✔	✔	✔
Tear Strength	3.2.4	✔	✔	✔	✔
Puncture Resistance	3.2.5	✔	✔	✔	✔
Porosity	3.2.7	✔	✔	✔	✔
Flex Cracking	3.2.8	✔	✔	✔	✔
Low Temperature Flexing	3.2.9		✔		✔
Oil Resistance	3.2.10	✔	✔	✔	✔
Reference: Transport Canada, "Material Specification For Coated Fabrics Used in the Manufacture of Inflatable Liferafts", TP-1324, February 1992; plus amendments.					

6.0 RESULTS

This section presents both the results of the various experiments and the analysis and interpretation of the results.

6.1 HISTORICAL INSPECTIONS

6.1.1 LIDS

The LIDS program was unsuccessful in the scope of this project. The program was developed successfully and is now fully functional. However, the inspection depots do not use it, despite their assurances that they would implement the LIDS program and the hand-held computers. This seems to be more a failure in marketing or enforcing the use of the program, rather than the program itself. Nevertheless, if implemented, LIDS could still provide Transport Canada with a current record of inspected liferafts and their histories, while reducing costs, paperwork and complexity, and assisting in regulatory measures.

6.1.2 AGE DISTRIBUTION

The age distribution of liferafts in the database is tabulated in Table 6.1 and shown graphically in Figures 6.1, 6.2 and 6.3. The average age of all liferafts in the database is 12.18 years. As may be expected, the average age of condemned liferafts (21.80 years) is significantly greater than that of serviceable liferafts (11.24 years).

Table 6.1 Database Liferaft Age Distribution

DATE OF MANUFACTURE	AGE	NUMBER OF LIFERAFTS		
		TOTAL DATABASE	SERVICEABLE	CONDEMNED
2000	1	122	121	0
1999	2	60	60	0
1998	3	62	62	0
1997	4	52	52	0
1996	5	44	44	0
1995	6	46	46	0
1994	7	47	45	2
1993	8	41	41	0
1992	9	24	24	0
1991	10	46	46	0
1990	11	51	50	1
1989	12	80	74	6
1988	13	40	34	7
1987	14	39	36	3
1986	15	79	78	1
1985	16	108	104	4
1984	17	73	73	0
1983	18	69	64	5
1982	19	22	17	5
1981	20	47	37	10
1980	21	11	10	1
1979	22	25	14	11
1978	23	29	18	11
1977	24	37	24	13
1976	25	24	17	7
1975	26	14	5	9
1974	27	23	12	11
1973	28	7	3	4
1972	29	5	1	4
1971	30	2	0	2
1970	31	0	0	0
1969	32	0	0	0
1968	33	2	0	2
1967	34	1	0	1
Totals		**1332**	**1212**	**120**
		100%	**91.0%**	**9.0%**
Average Age [years]		**12.18**	**11.24**	**21.80**

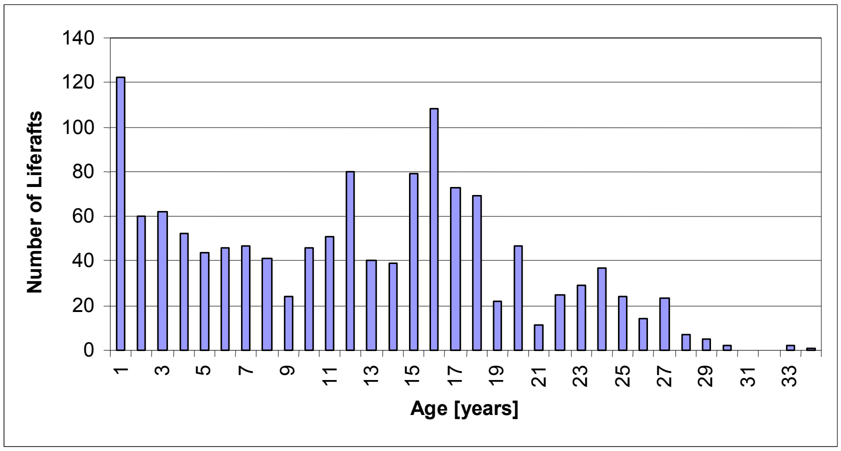

Figure 6.1 Liferaft Age – All Liferafts

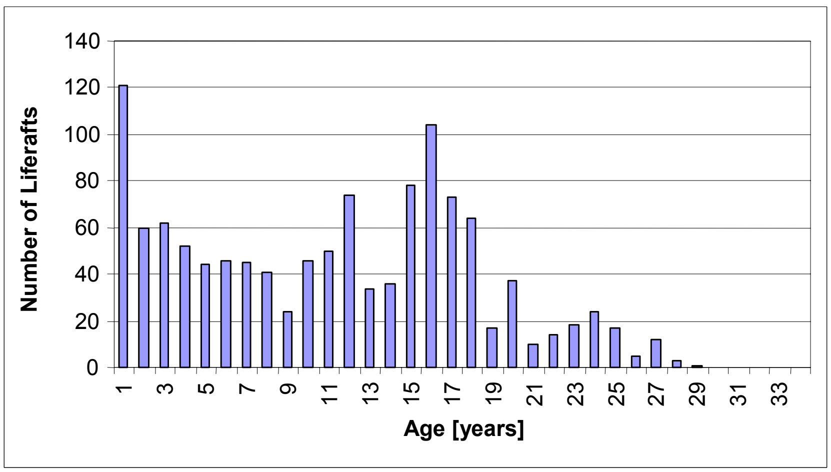

Figure 6.2 Liferaft Age – Serviceable Liferafts

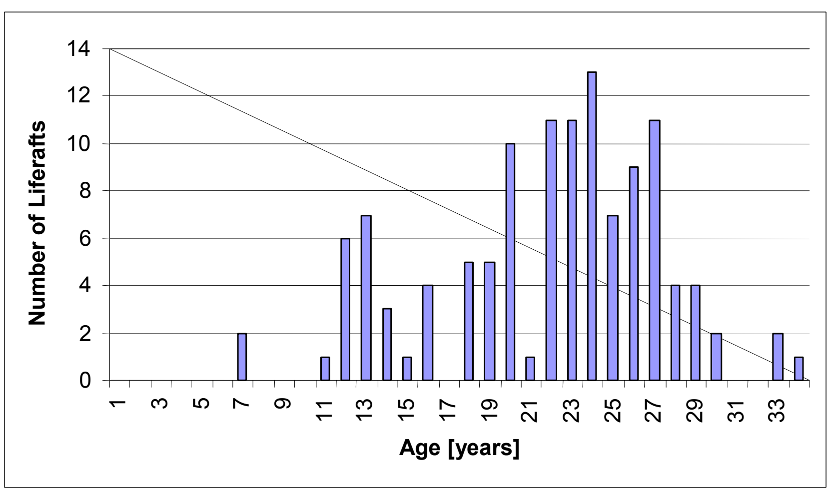

Figure 6.3 Liferaft Age – Condemned Liferafts

The distribution of the number of Condemned Liferafts v. Age may be generalized by fitting the following 4th order polynomial to the data presented in Figure 6.4:

$$\# \text{ Cond Liferaft} = -0.000031(\text{Age})^4 + 0.000029(\text{Age})^3 + 0.040536(\text{Age})^2 - 0.234609(\text{Age})$$

Integrating this polynomial and plotting based on the percentage of total area under the graph yields the condemned probability plot shown in Figure 6.5, indicating the probability that a condemned liferaft will have a given age.

An example inference from this graph would be: if a liferaft is condemned there is ~0.5% probability it is five years, ~5% probability it is ten years, and ~34% probability it is 20 years old or less. Alternatively read, there is ~99.5% probability it is older than five years, ~95% probability it is older than ten years, and ~66% probability it is older than 20 years. Note that the above statistical analysis provides insight only to the characteristics of condemned liferafts. It does not mean that if we inspect a liferaft that is ten years old or less that there is a 5% probability it will be condemned.

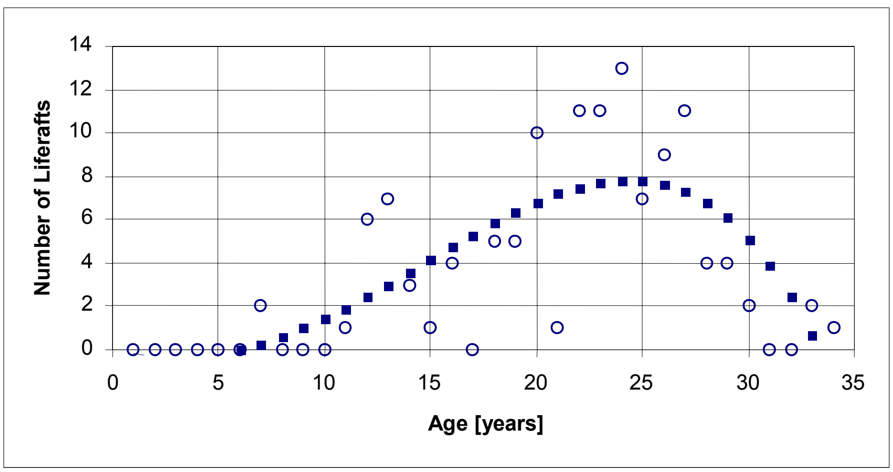

Figure 6.4 Polynomial Fit of Condemned Liferaft Age Distribution

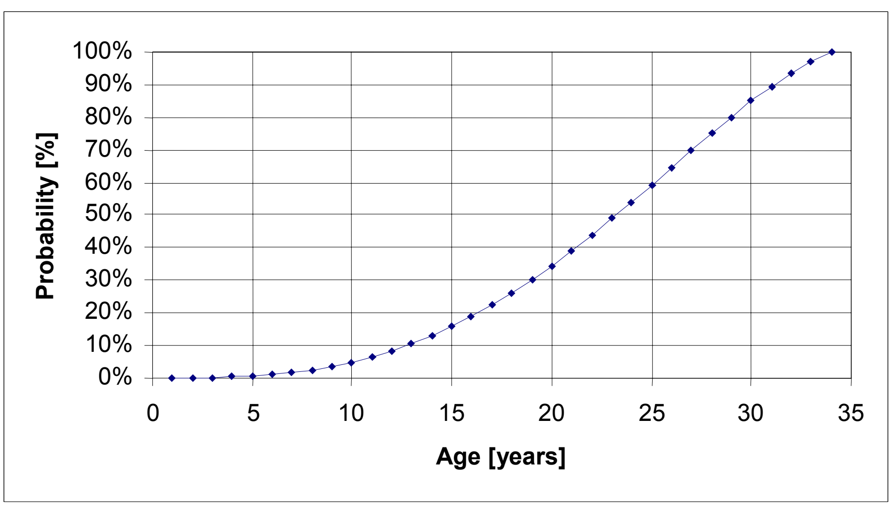

Figure 6.5 Condemned Age Probability Plot

To infer the probability that a liferaft of a given age will we be condemned, the total database must be analyzed. With the current database (limited number of inspection forms for certain ages), some data filtering must be done before analysis can be done. Figure 6.6 below plots the percentage of liferafts that were Condemned v. Liferaft Age. This scattered raw data may be filtered using a 5-year running average; also plotted on Figure 6.6 for liferaft ages of 3 to 28 years. A 4th order polynomial series fit to this filtered data (shown as solid line) yields the equation for Condemned Probability:

$$CP = 0.0000008(Age)^4 + 0.0000124(Age)^3 – 0.0002344(Age)^2 + 0.0025868(Age)$$

Using this formula, we can infer that the probability of condemning a liferaft during inspection is as follows:

- 0.9% for a five-year-old liferaft
- 2.3% for a ten-year-old liferaft
- 6.8% for a 15-year-old liferaft
- 18.5% for a 20-year-old liferaft

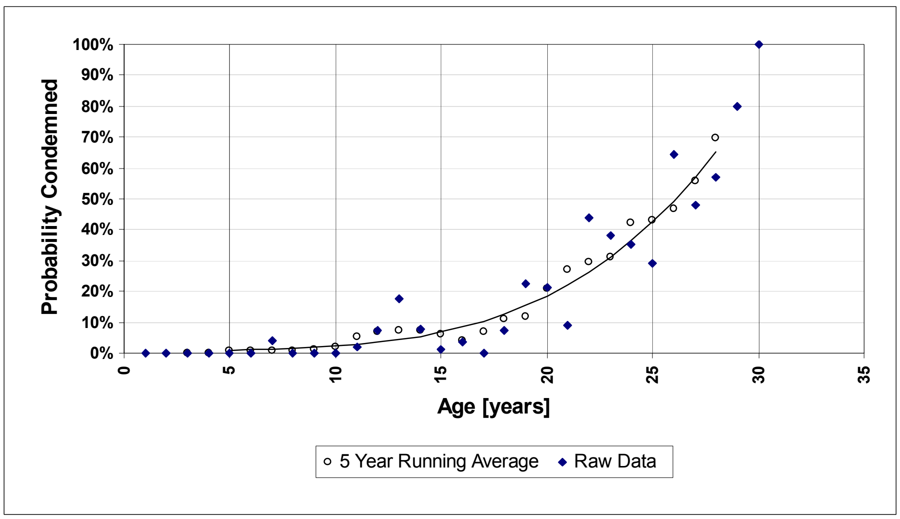

Figure 6.6 Condemned Probability Plot: Non-Annual Inspections

Since not all liferaft owners have adhered to annual inspections, this is a presentation of the probability based on the current system in practice and not on annual inspections, which does not occur for all liferafts. For an analysis of the current system according to regulations, the database must be limited to liferafts with an inspection interval of 1 year (1.5 years to allow for shipping). Applying the method used to arrive at the Condemned Probability for the entire database, a 4th order polynomial is fit to the five-year filtered data, shown in Figure 6.7:

$$CP = 0.00000135(Age)^4 – 0.00000968(Age)^3 – 0.00006888(Age)^2 + 0.00192139(Age)$$

Using this formula, we can infer that the probability of condemning a liferaft during inspection is as follows:

- 0.8% for a five-year-old liferaft
- 1.63% for a ten-year-old liferaft
- 4.9% for a 15-year-old liferaft
- 14.9% for a 20-year-old liferaft

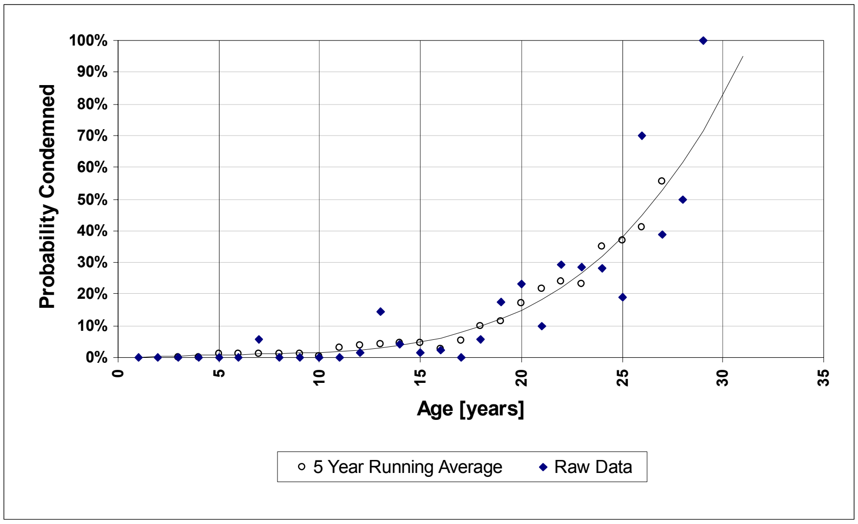

Figure 6.7 Condemned Probability Plot: Annual Inspections

6.1.3 SERVICE INTERVAL DISTRIBUTION

The distribution of service intervals (time since last inspection) is tabulated in Table 6.2 and shown graphically in Figures 6.8, 6.9 and 6.10. The distribution shows general conformance to regulatory requirements with 79.6% of the records having a service interval of 18 months or less. Regulatory conformance for serviceable liferafts (81.8%) is significantly higher than for liferafts that were condemned (56.7%). This suggests that poor regulatory conformance or non-adherence to an inspection interval may increase the chances of a liferaft being condemned.

Table 6.2 Liferaft Inspection Service Intervals

Service Interval [Years]	Quantity		
	Total Database	Serviceable	Condemned
< 1	260	235	25
1 – 1.5	800	757	43
1.5 – 2	80	70	10
2 – 3	91	76	15
3 – 4	30	28	2
4 – 5	30	22	8
> 5	41	24	17
	Accumulated Quantity [%]		
< 1	260 [19.5]	235 [19.4]	25 [20.8]
1 – 1.5	**1060 [79.6]**	**992 [81.8]**	**68 [56.7]**
1.5 – 2	1140 [85.6]	1062 [87.6]	78 [65.0]
2 – 3	1231 [92.4]	1138 [93.9]	93 [77.5]
3 – 4	1261 [94.7]	1166 [96.2]	95 [79.2]
4 – 5	1291 [96.9]	1188 [98.0]	103 [85.8]
> 5	1332 [100]	1212 [100]	120 [100]
Average Service Interval [days]	**573.4**	**530.5**	**1006.0**

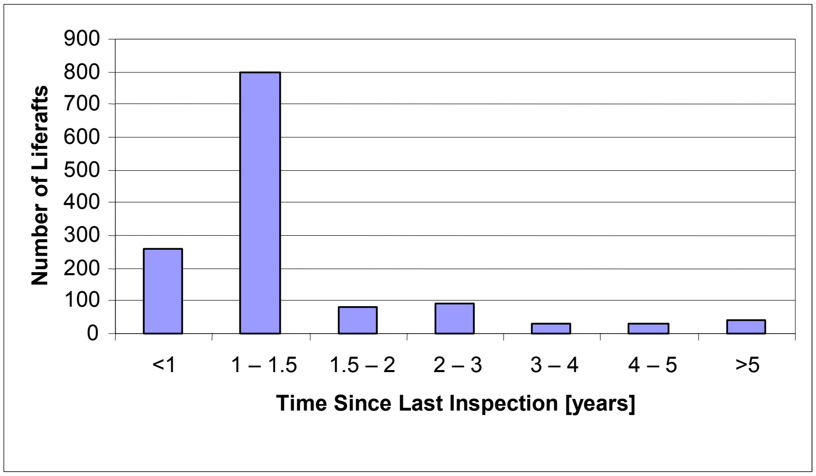

Figure 6.8 Inspection Interval – All Liferafts

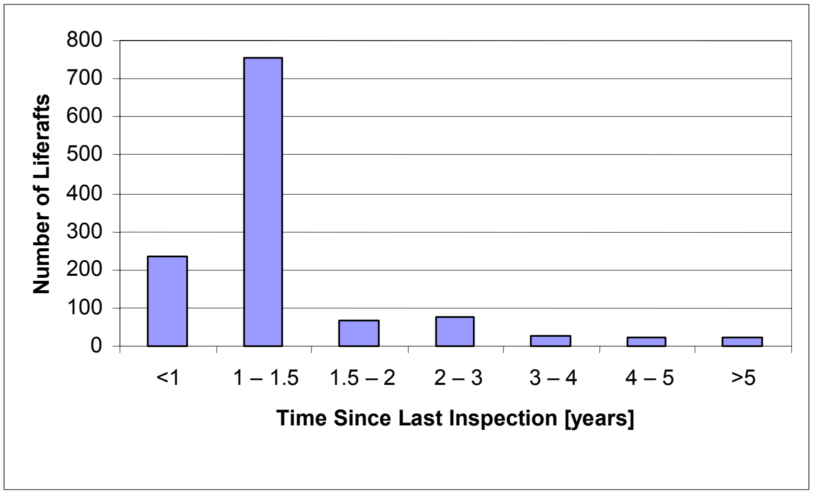

Figure 6.9 Inspection Interval – Serviceable Liferafts

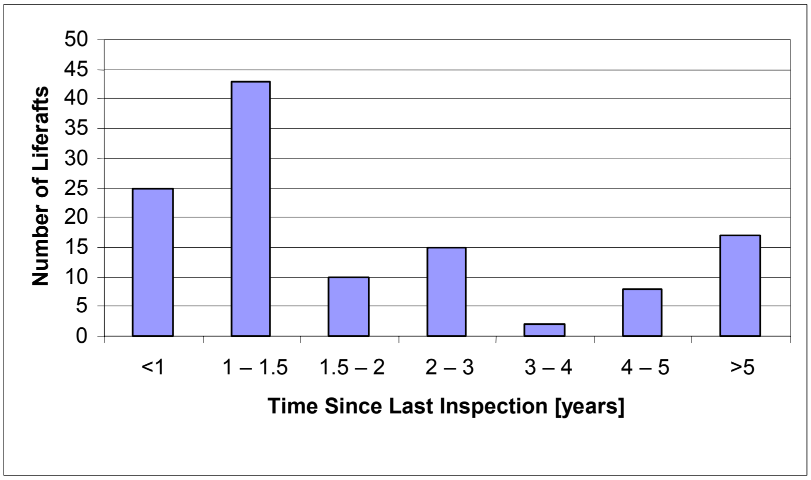

Figure 6.10 Inspection Interval – Condemned Liferafts

Table 6.2 also shows the average service interval for each dataset. Of particular interest is the difference between the average for serviceable liferafts (530.5 days) and condemned liferafts (1006.0 days). This indicates liferafts that have been condemned have had comparatively poor inspection histories.

The regulatory requirement is a 12-month inspection interval. However, regulatory conformance under this analysis has been based on an 18-month interval allowing a 6-month grace period for shipment to and from the service depot.

Of further importance is a recent directive (now an amendment to the CSA) from Transport Canada regarding liferafts utilized on seasonal vessels. The directive stipulates that an inspection interval of 24 months is acceptable if the liferaft is suitably stored in a dry place in the off season. Transport Canada has recently proposed a service interval of 30 months for liferafts designed specifically for extended service. It is not possible to determine the number of database records affected by this.

6.1.4 Problem Incidence

Table 6.3 below shows the number of incidents by problem category reported; problem categories are defined in Section 3.1. Note that a single record (liferaft) might have more than one problem. That is, an individual record may show buoyancy material repair, CO_2 system repair and painter replacement (three incidents reported on the same inspection form). The fact that 589 problem incidents reported in the total database are attributable to 473 liferafts illustrates this point.

Table 6.3 Liferaft Problem Incidents

PROBLEM CATEGORY		NUMBER OF INCIDENTS		
		TOTAL DATABASE	SERVICEABLE	CONDEMNED
A	Buoyancy Material Repair	149	45	104
B	Canopy Material Repair	2	2	0
C	CO_2 System Repair	94	86	8
D	Other Repairs	104	104	0
E	Canister Repairs	105	104	1
F	Painter Replacement	43	43	0
G	Valise Replacement	92	92	0
	Total	**589**	**476**	**113**
# Liferafts with Problems		**473 [35.5%]**	**364 [30.0%]**	**109 [90.8%]**
# Liferafts with Critical Problems		**237 [17.8%]**	**128 [10.6%]**	**109 [90.8%]**
# Liferafts in Database		**1332**	**1212**	**120**

Table 6.3 indicates that from the total database, the most common problem categories were buoyancy material problems (25% incident rate) followed by canister problems (18% incident rate). However, most condemned liferafts had problems with the buoyancy material (92% incident rate), whereas all other problems were negligible.

Table 6.3 also notes the frequency of canister damage: 104 incidents were noted in the database of 1212 non-condemned liferafts, at an 8.6% incident rate. The average age of these liferafts is ~13.5 years, ~2.3 years older than average age of all serviceable liferafts; indicating older liferaft canisters are more likely to have problems. However, there is no way to deduce from inspection form data if canister damage is sustained onboard or from installation/removal during the ship and transport from/to the service depot.

Of particular interest in Table 6.3 is the number of serviceable liferafts (non-condemned) that had “critical” problems: 128 of 1212 records (10.6%). Figure 6.11 below shows the age distribution of these liferafts. The average age of these liferafts was 13.26 years; 2.02 years older than the average age of all serviceable liferafts (11.24 years), indicating that older liferafts are more likely to have critical problems.

The average service interval for the 128 serviceable liferafts with critical problems is 580.6 days. This may be compared to the average service interval for all serviceable liferafts, which is 530.5 days. The conclusion here, as may be expected, is that serviceable liferafts with critical problems have had longer service intervals than those without critical problems.

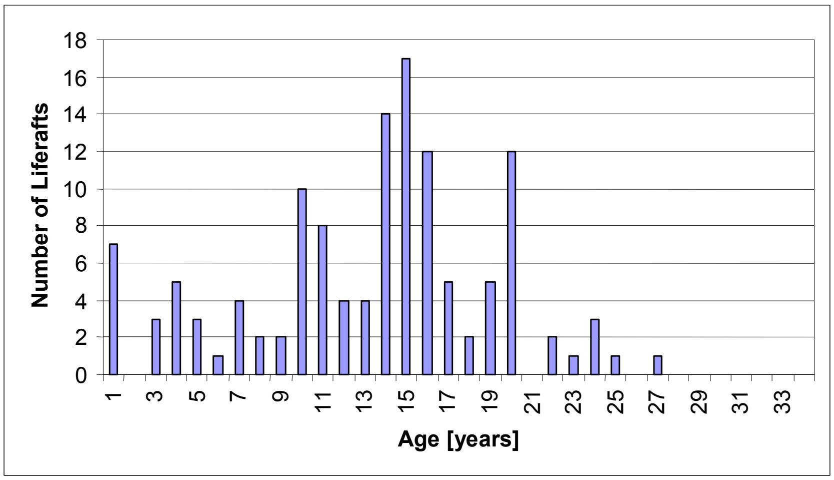

Figure 6.11 Liferaft Age – Critical Problem Serviceable Liferafts

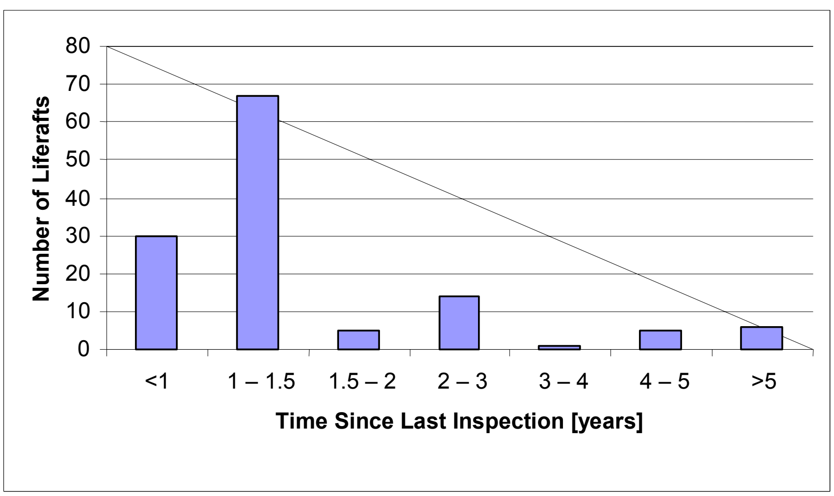

Figure 6.12 Inspection Interval – Critical Problem Serviceable Liferafts

Using a similar five-year filter and polynomial fit method to that of deriving Condemned Probability illustrated by Figure 6.6, one can arrive at Critical Problem Probability v. Liferaft Age. Figure 6.13 shows that the probability of a critical problem occurring is ~5% at less than four years of age. The probability rapidly increases with age past four years and peaks at 16 years, with the bulk of cases between ten and 20 years. The probability decreases past 20 years, most likely because the majority of liferafts with problems fail at this point and the remaining liferafts are well-maintained.

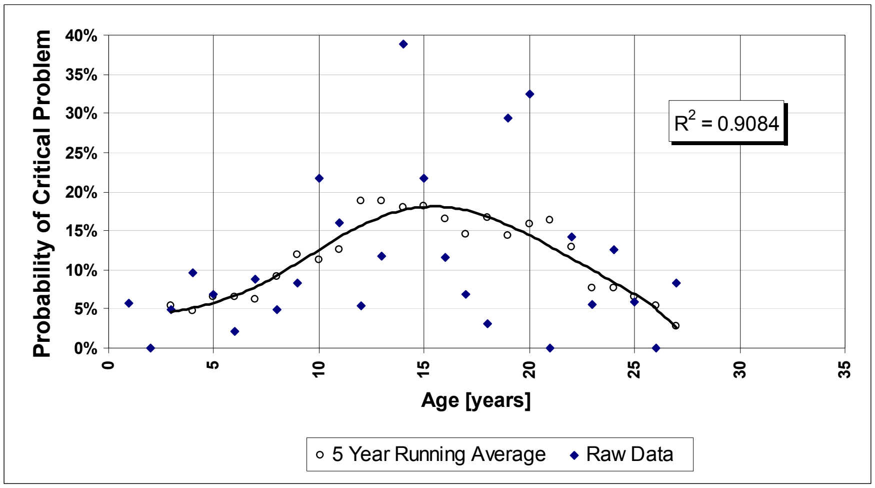

Figure 6.13 Critical Problem Probability Plot

6.2 FIELD TRIALS

6.2.1 DATA LOGGER RESULTS

The purpose of the collected data was to provide an indication of what environmental conditions liferafts (inside their canisters) are subjected to.

According to Figures 6.14 and 6.15, liferafts across Canada are exposed to temperatures of 10 – 20°C for ~50% of the time and temperatures of 0 – 10°C for another 30% of the time, while they are exposed to relative humidity (RH) of 80-90% for ~40% of the time, RH 70-80% for ~20% of the time and RH 90-100% for ~20% of the time. In addition, the ShockLog indicated that typically liferafts experienced negligible motion. However, the average non-zero acceleration was ~0.2g in X, Y and Z directions. Acceleration distribution is illustrated in Figures 6.16 – 6.18. This is not believed to put undue stress on the liferaft materials or canister.

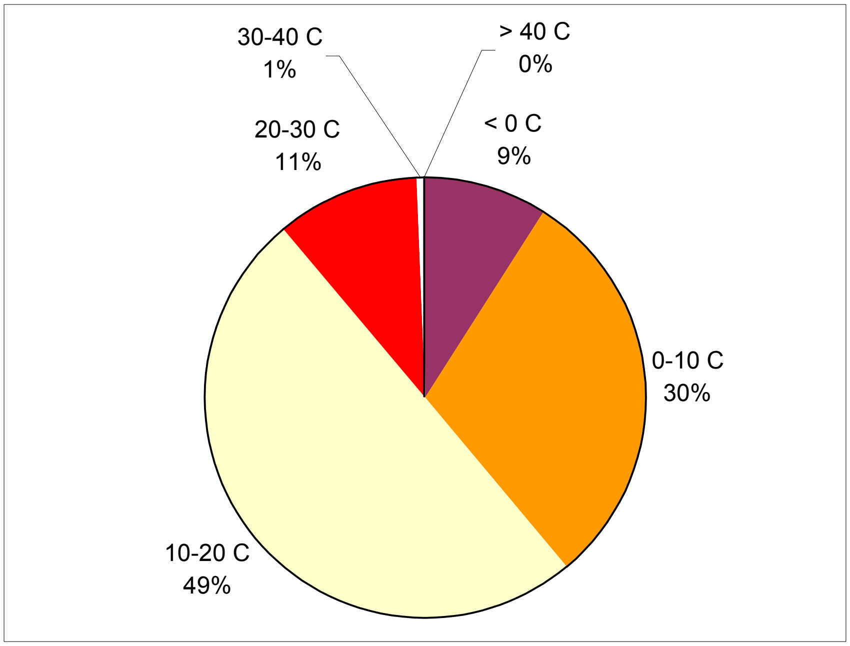

Figure 6.14 Temperature Experienced by Liferafts Across Canada

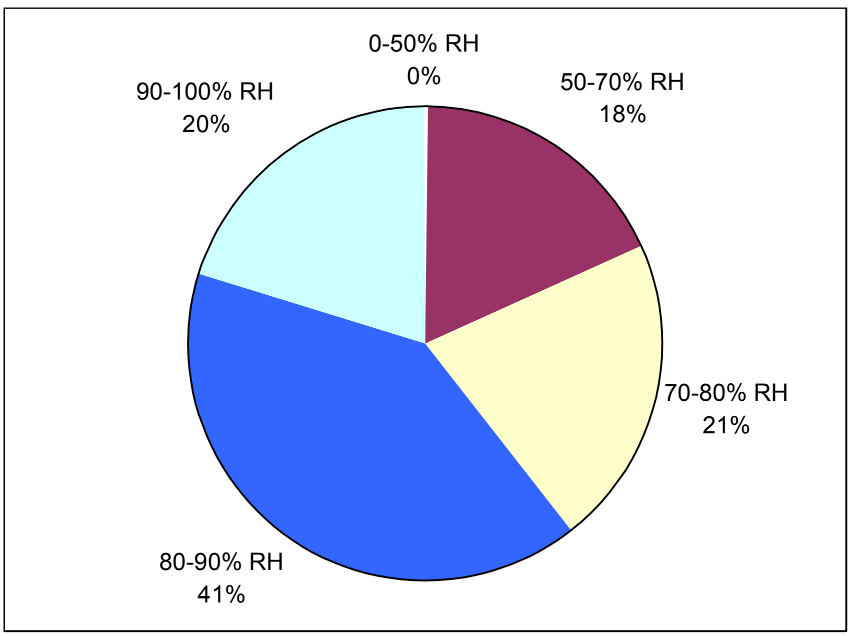

Figure 6.15 Relative Humidity Experienced by Liferafts Across Canada

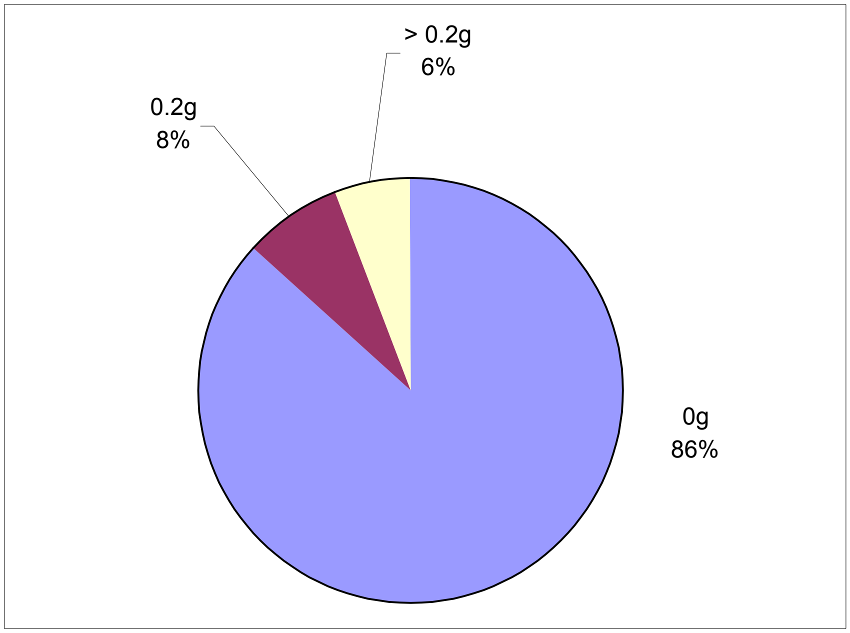

Figure 6.16 Canister Acceleration-X as Recorded by ShockLog

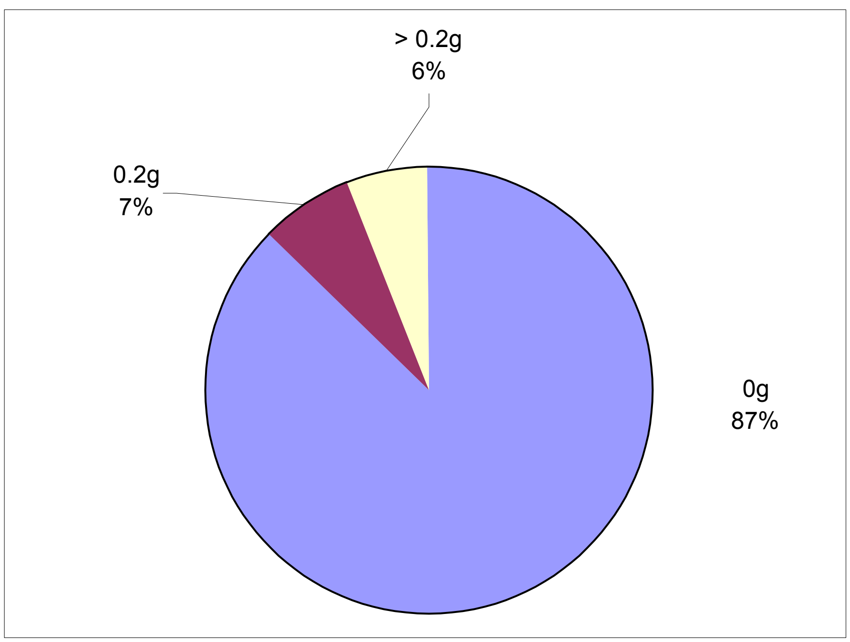

Figure 6.17 Canister Acceleration-Y as Recorded by ShockLog

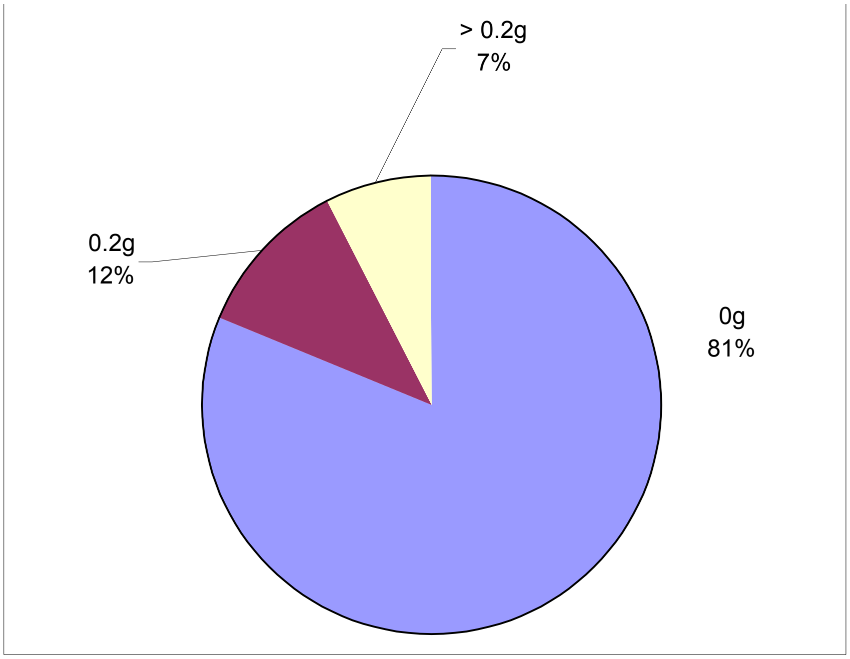

Figure 6.18 Canister Acceleration-Z as Recorded by ShockLog

6.2.2 DEPOT INSPECTIONS

After spending extended periods of time in the field, the trial liferafts were returned to the inspection depot for examination. All trial liferafts inflated without incident and with the exception of minor replacements, would pass a standard service interval inspection.

It should be noted that inflation system maintenance and replacement of pyrotechnics and rations were sometimes necessary, but this is part of a normal inspection, and does not affect the lifesaving reliability of the liferaft. As a minimum, a new liferaft may serve reliably without servicing for four years and may re-enter service after an inspection, which provides some evidence that the service interval may be extended. It is important to observe that although a new liferaft may survive four years without inspection, the service interval itself should not be extended to four years without further evidence of liferaft ageing and failure.

6.2.3 MATERIAL TESTS

Several material samples were taken from the experimental liferafts and inflatable platforms at different times over the course of the project. This testing was carried out to establish what, if any, changes occurred in the material properties over time. The investigation was focused only on the material properties for which requirements are set out in TP-1324.

The expected result prior to testing was that there would be a gradual reduction in material properties over time. For example, breaking strength would be less after four years in the field than that after two years in the field or at time of fabrication (new material). If changes in material properties were negligible or reduced but still within the requirements dictated by TP-1324, then it could be scientifically argued that concerns over material degradation were not an issue in considering extending the liferaft service interval within the first four years of service.

Table 6.4 summarizes the material properties of concern, the requirements set out by TP-1324, data from the material supplier and results from testing on new samples and samples taken over the duration of the project. Data contained within this table is plotted in Figures 6.19 – 6.22.

Table 6.4 Basic Test Summary of Results

TP 1324	Test Description	W/F	Units	Req'd	A Material Manufacturer Reported	B New Samples (DBC)	C1 8439-10/15-IBA (~19 months)	C2 8446-10/15-IBA (~32 months)	C3 8698-6FT (~32 months)	C4 8669-10/15-IBA (~34 months)	C5 8697-6FT (~34 months)
					Material Test Results						
					BUOYANCY MATERIAL						
3.2.1	Weight		[gm/m2]	<= 655	416.3			425.0	428.5	433.3	459.2
3.2.2	Breaking Strength	W	[N]	>= 2400	4075	4,137.0	4,089.0	3,998.0	3,810.0	3,994.0	3,929.0
		F	[N]	>= 2000	3919	2,944.0	3,099.0	3,152.0	2,992.0	2,831.0	3,046.0
3.2.3	Elongation at Break	W	[%]	<= 35	24.8	27.0	24.9	24.7	23.1	24.1	25.4
		F	[%]	<= 35	27.5	25.1	25.7	24.7	24.2	23.6	26.5
3.2.4	Tear Strength	W	[N]	>= 1000	1848	1,641.0	1,842.0	1,947.0	1,891.0	1,970.0	1,906.0
		F	[N]	>= 900	1546	1,876.0	1,625.0	1,701.0	1,638.0	1,709.0	1,733.0
3.2.5	Puncture Resistance		[N]	>= 700	1070	1,005.0	886.0	978.7	1,012.0	1,032.2	1,056.9
3.2.7	Porosity		B	< 15	0	0	0	0	0	0	0
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass	pass	pass	pass
		delamination	I	none	pass	pass	pass	pass	pass	pass	pass
		porosity	B	<= 2	0	fail	pass	fail	fail	fail	pass
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass	pass	pass	pass
	(@ 20C +/- 2C)	tackiness	I	none	pass	pass	pass	pass	pass	pass	pass

B = # of bubbles, I = # of incidents

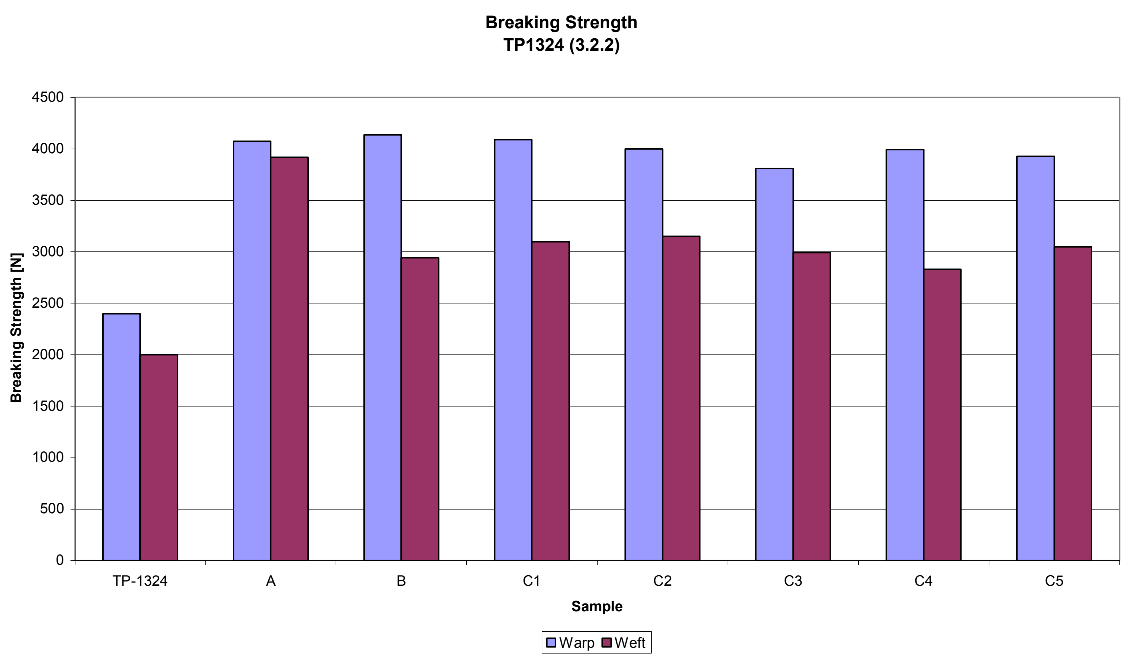

Figure 6.19 Breaking Strength of Liferaft Samples

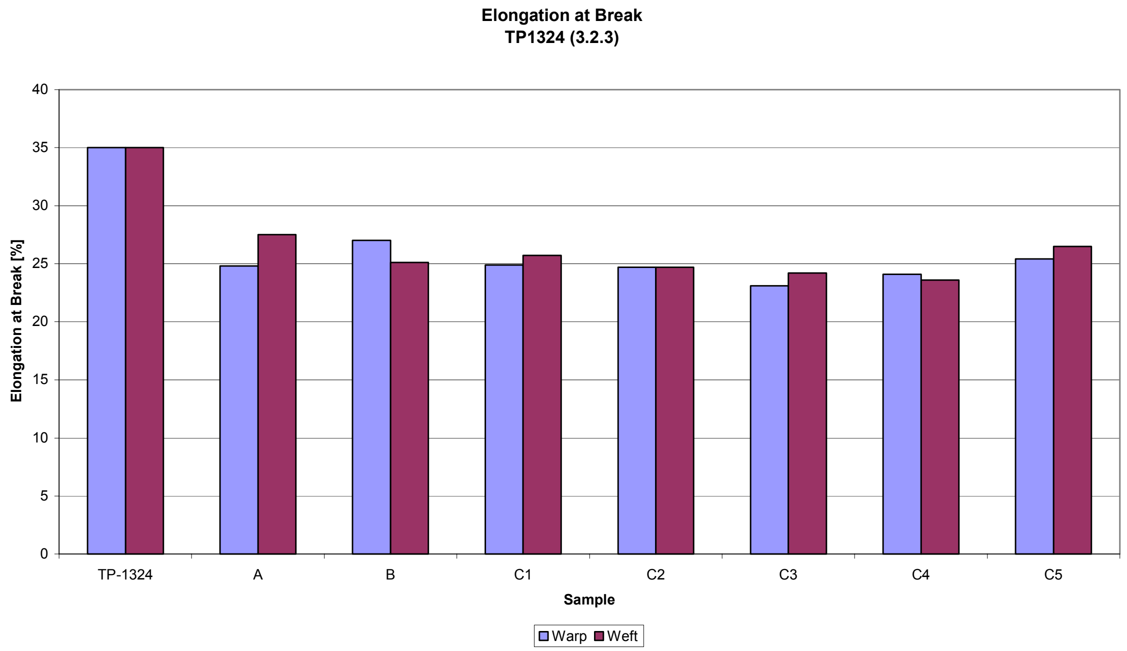

Figure 6.20 Elongation of Liferaft Samples

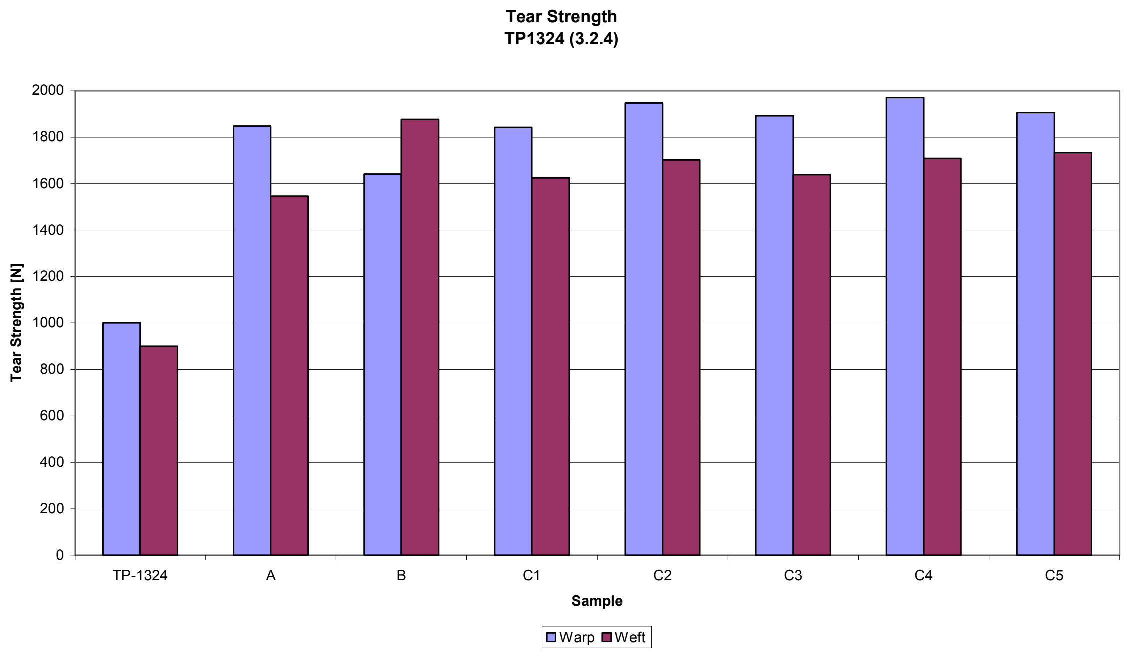

Figure 6.21 Tear Strength of Liferaft Samples

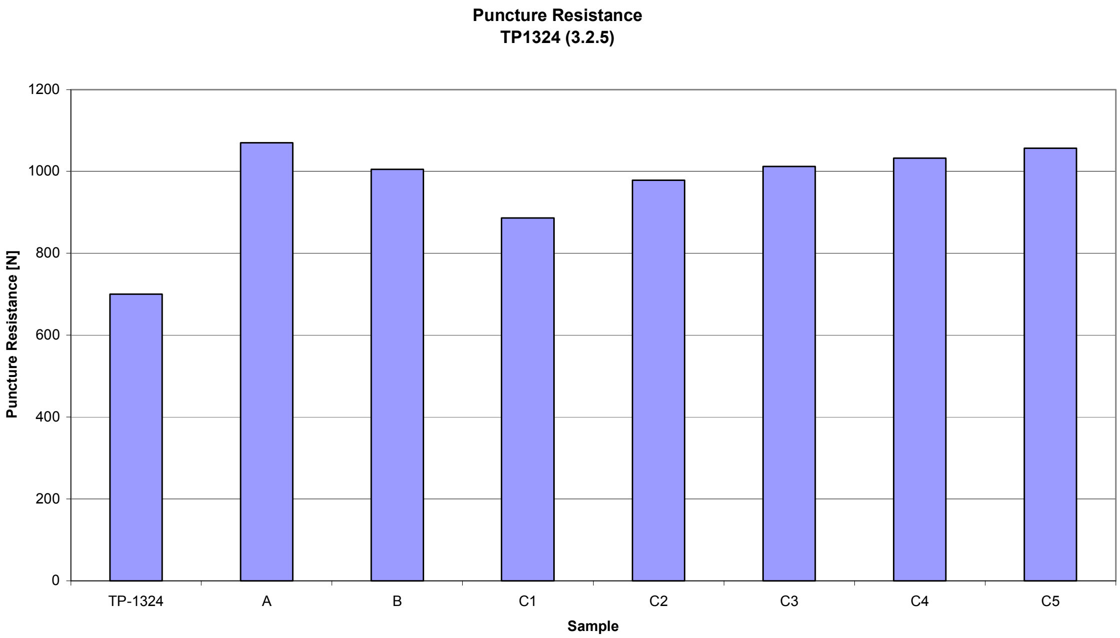

Figure 6.22 Puncture Resistance of Liferaft Samples

The test results shown in the above figures indicate that the material properties all exceed TP-1324 requirements and do not change significantly with time. However, Table 6.4 indicates that a number of materials failed the Flex Cracking test. These same materials passed standard liferaft inspections without problems and otherwise pass all TP-1324 requirements. These incongruent results may be an indication that the Flex Cracking requirement, as outlined by the TP-1324 document, is too stringent and may require re-evaluation. In all other respects, the results revealed little change in material properties and whatever change observed is believed to be within the variance expected in material sampling and testing.

This demonstrates that after four years, a new liferaft will retain its material properties well above those stipulated by TP-1324. Although encouraging, this is not sufficient to justify a service interval extension. A liferaft could re-enter service after four years, but could conceivably fail after only two more years of service (six years old) and not four more years. Although the trends in material properties indicate a longer safe life, accelerated ageing tests, which will age the material to the point of failure, are required to substantiate these trends.

6.3 ACCELERATED AGING MATERIAL TESTING

Testing was conducted by the Centre for Textile Technologies [7] on two samples of each material type (Butyl, Polyurethane, and Rubber). Test results are summarized in the sections below, while full material property details are available in Appendix D.

6.3.1 BUTYL MATERIAL

Figures 6.23 – 6.27 show plots of Material Properties v. Artificial Age (0, 10, 15 and 20 years) for Weight, Breaking Strength, Elongation at Break, Tear Strength and Puncture Resistance respectively.

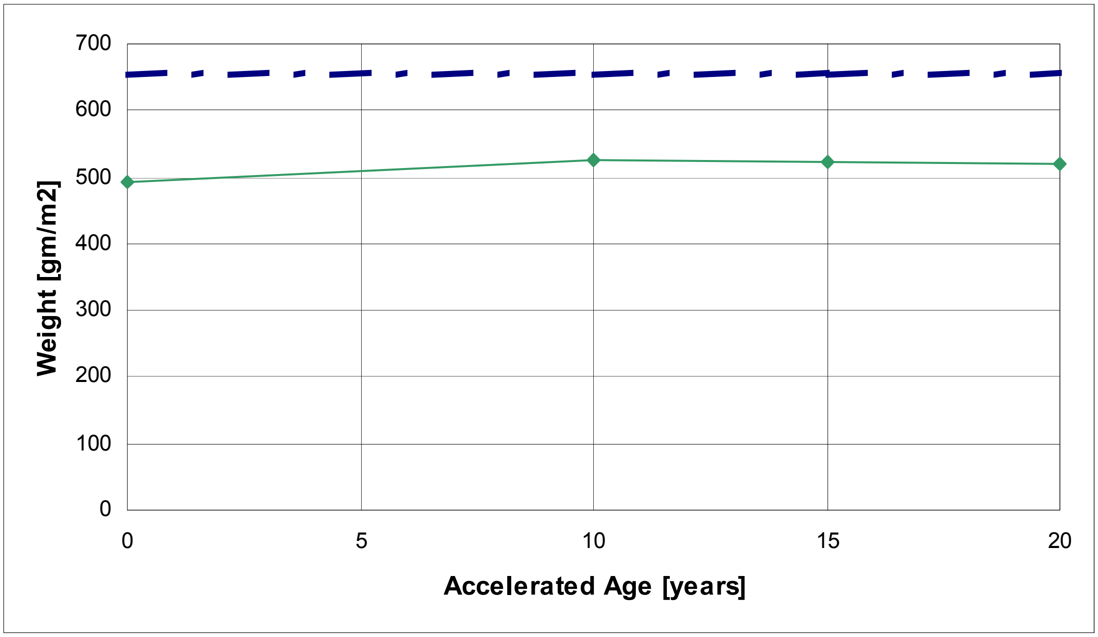

Figure 6.23 Butyl: Material Weight v. Accelerated Age

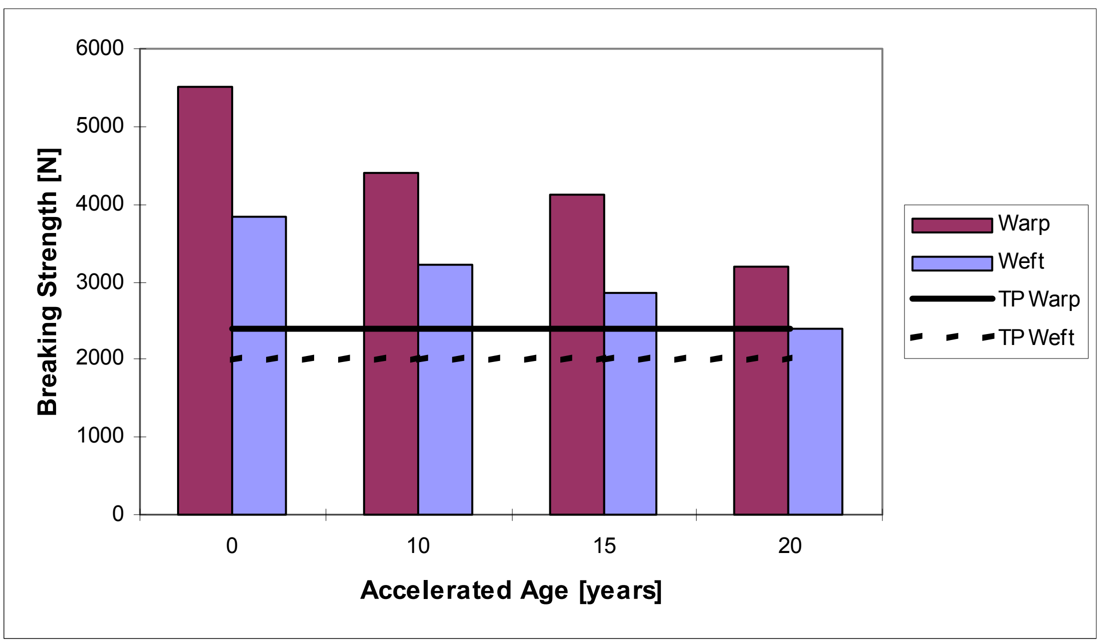

Figure 6.24 Butyl: Breaking Strength v. Accelerated Age

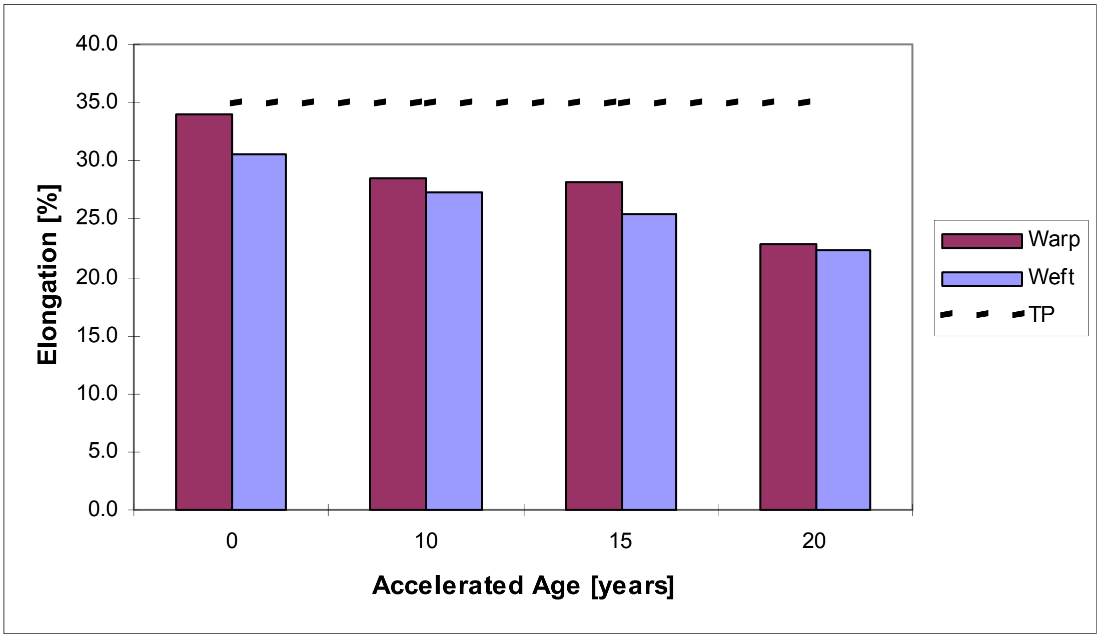

Figure 6.25 Butyl: Elongation v. Accelerated Age

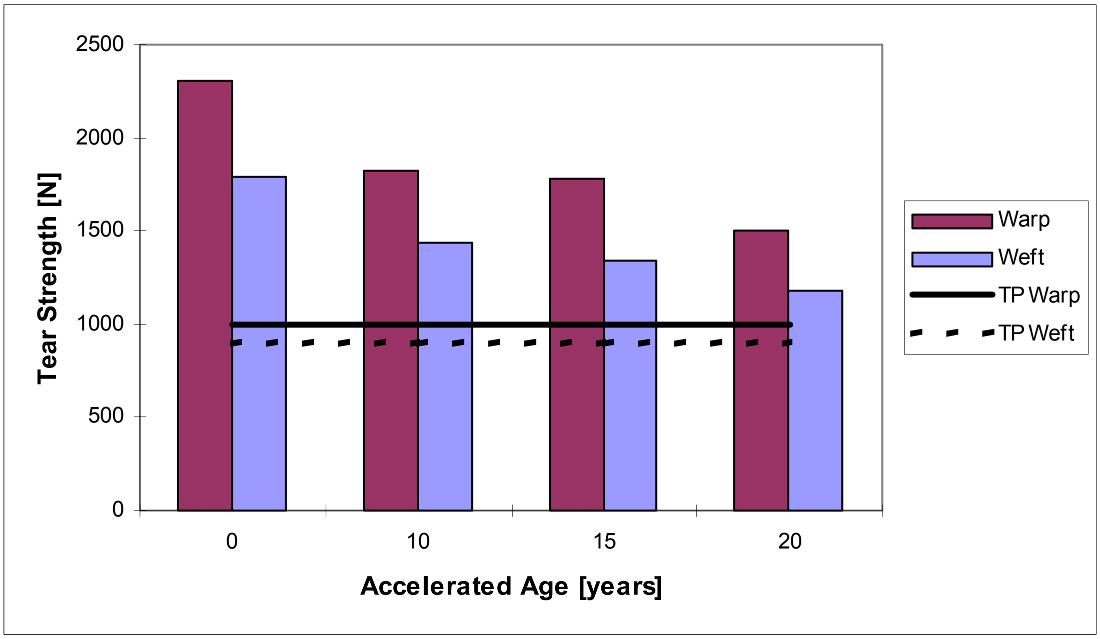

Figure 6.26 Butyl: Tear Strength v. Accelerated Age

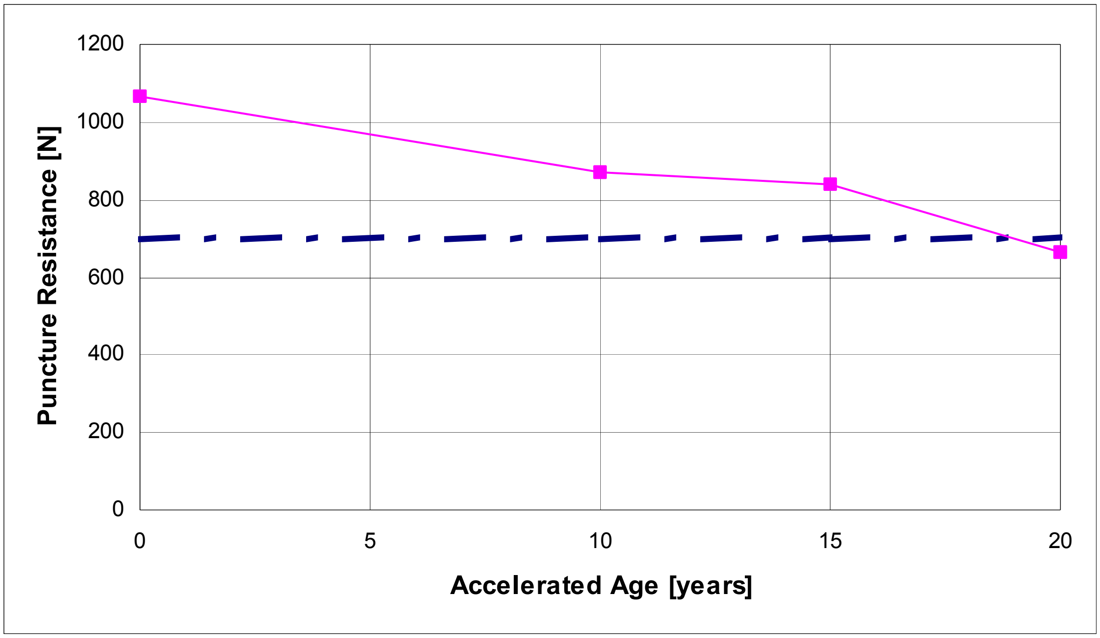

Figure 6.27 Butyl: Puncture Resistance v. Accelerated Age

6.3.2 POLYURETHANE MATERIAL

Figures 6.28 – 6.32 show plots of Material Properties v. Artificial Age (0, 10, 15 and 20 years) for Weight, Breaking Strength, Elongation at Break, Tear Strength and Puncture Resistance respectively.

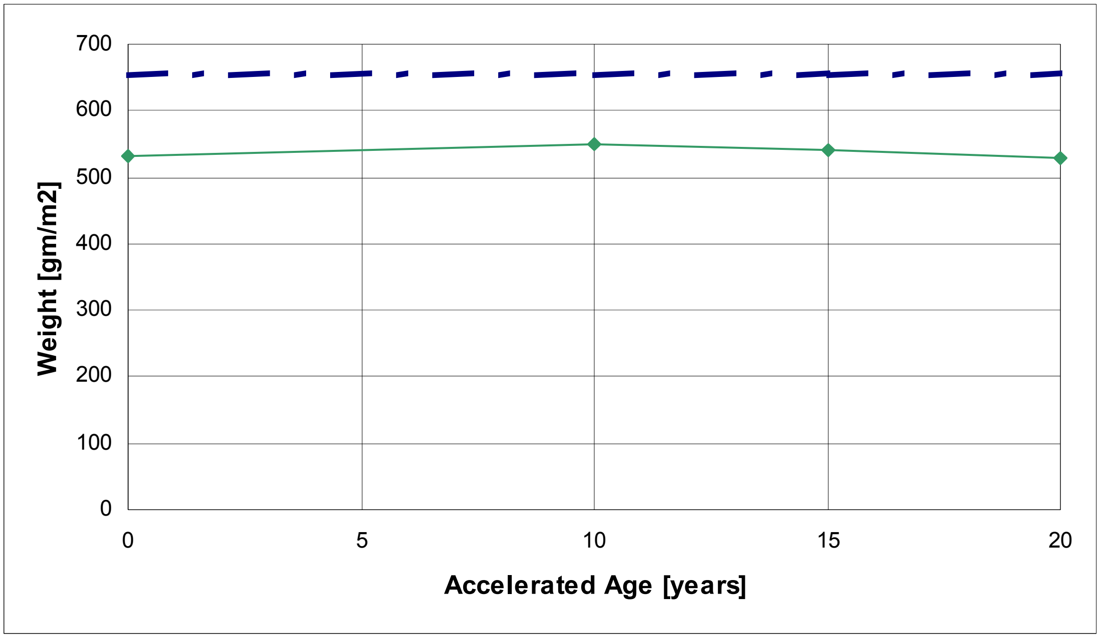

Figure 6.28 Polyurethane: Material Weight v. Accelerated Age

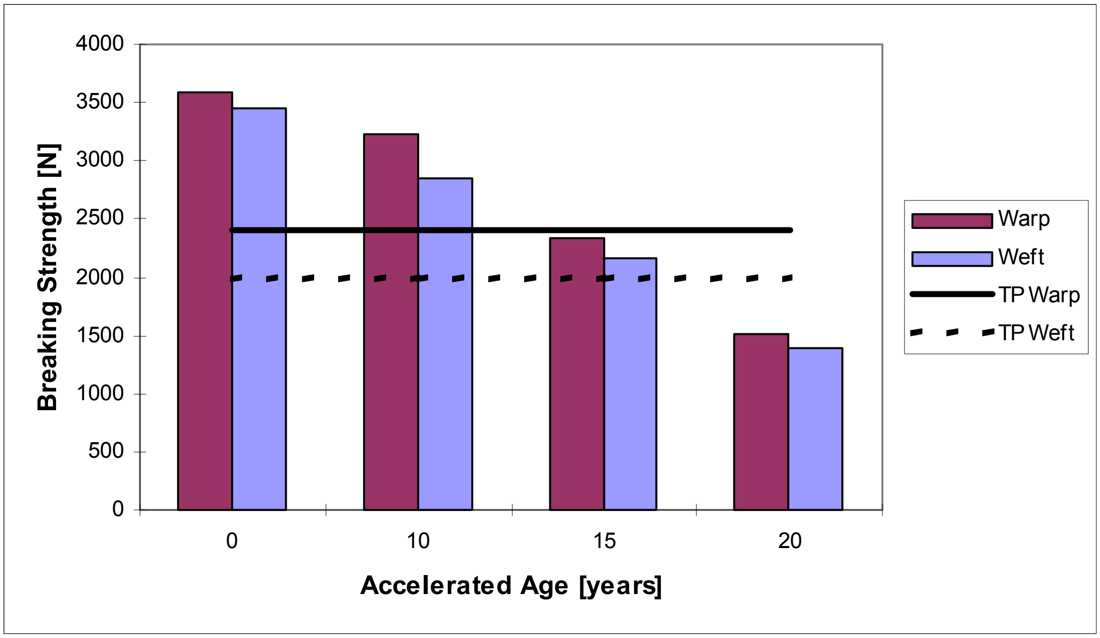

Figure 6.29 Polyurethane: Breaking Strength v. Accelerated Age

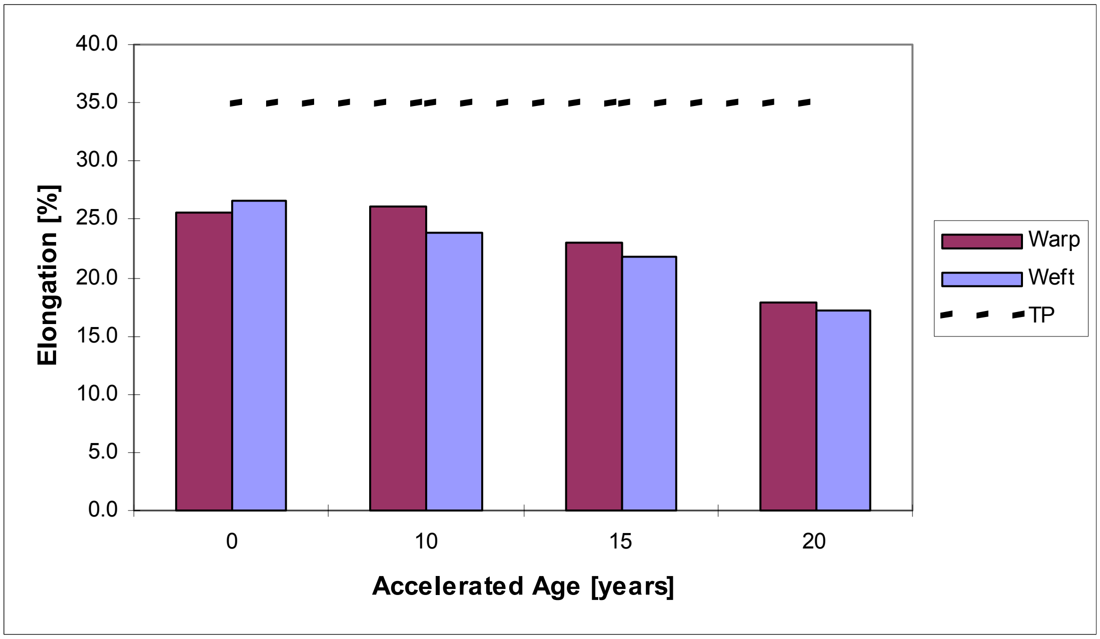

Figure 6.30 Polyurethane: Elongation v. Accelerated Age

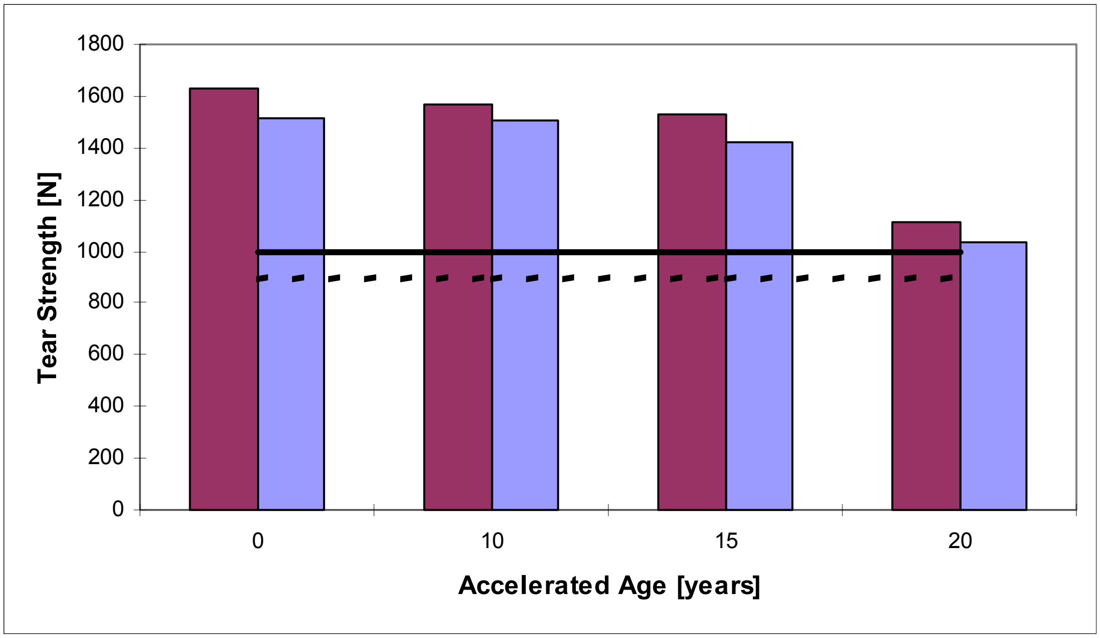

Figure 6.31 Polyurethane: Tear Strength v. Accelerated Age

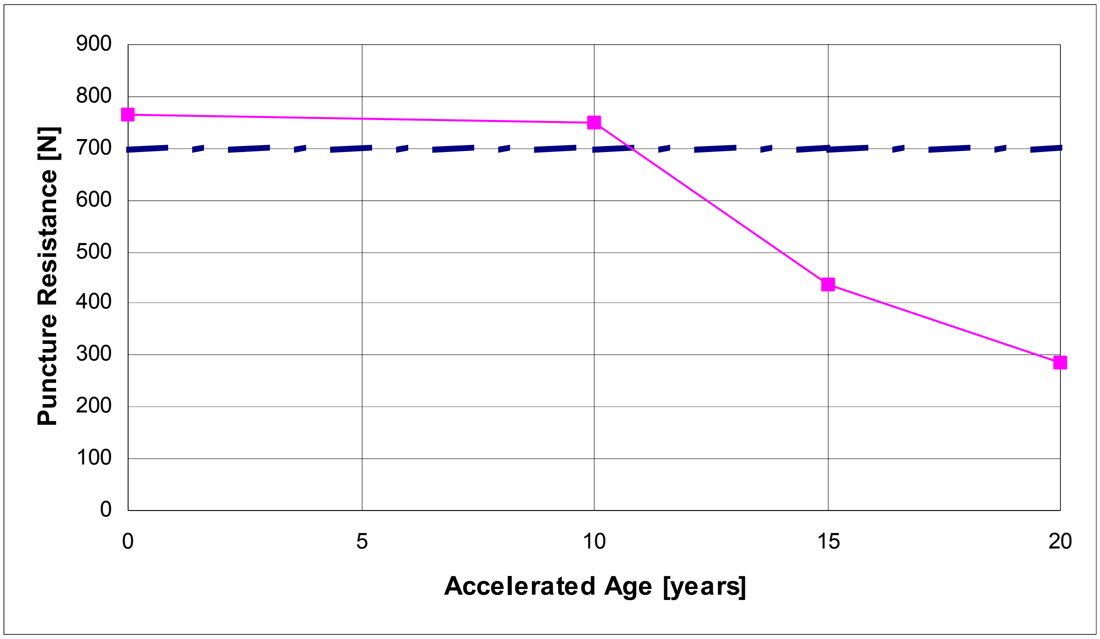

Figure 6.32 Polyurethane: Puncture Resistance v. Accelerated Age

6.3.3 Rubber-Based Material

Figures 6.23 – 6.27 show plots of Material Properties v. Artificial Age (0, 10, 15 and 20 years) for Weight, Breaking Strength, Elongation at Break, Tear Strength and Puncture Resistance respectively.

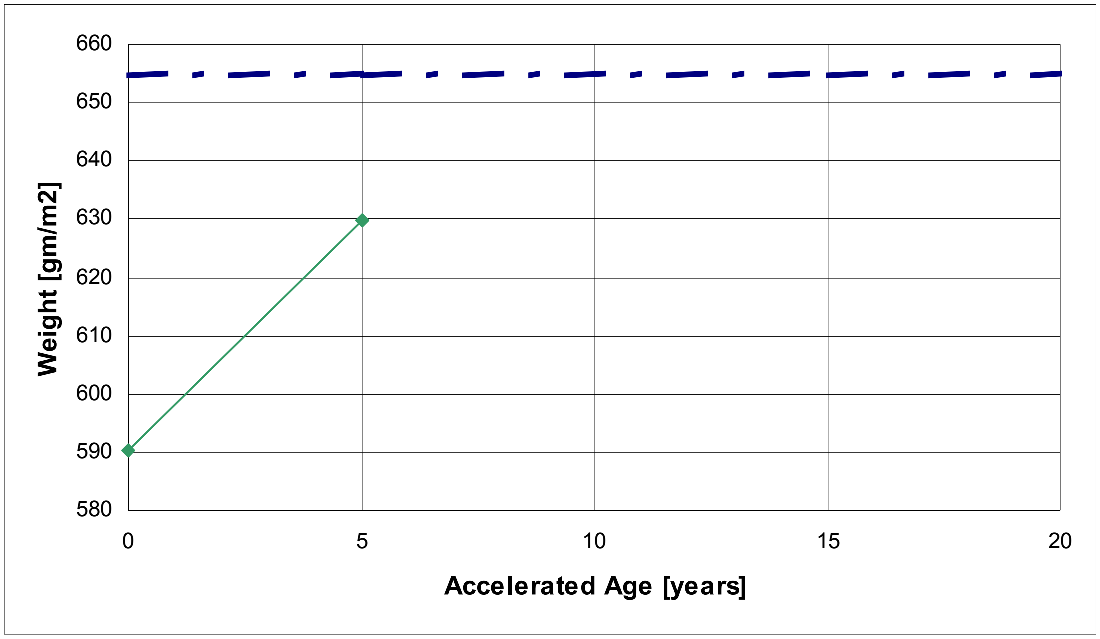

Figure 6.33 Rubber: Material Weight v. Accelerated Age

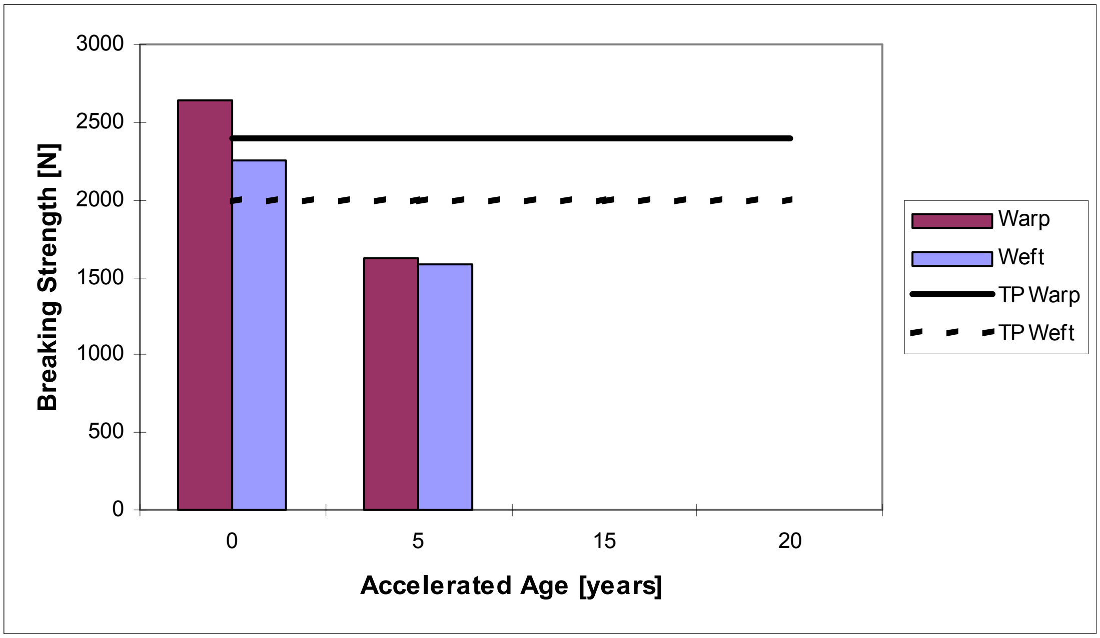

Figure 6.34 Rubber: Breaking Strength v. Accelerated Age

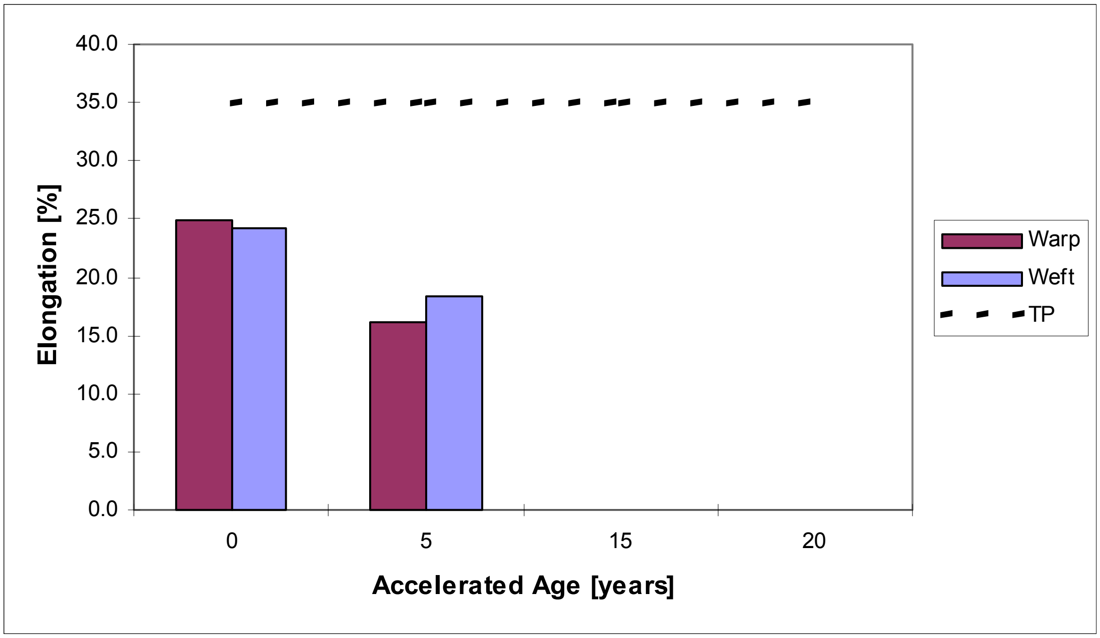

Figure 6.35 Rubber: Elongation v. Accelerated Age

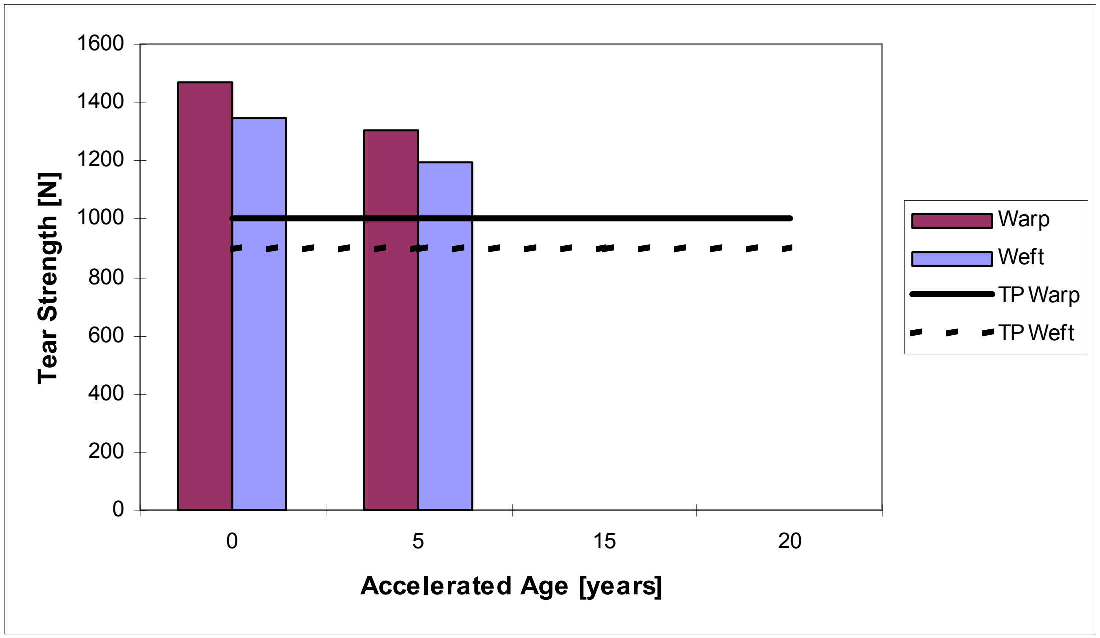

Figure 6.36 Rubber: Tear Strength v. Accelerated Age

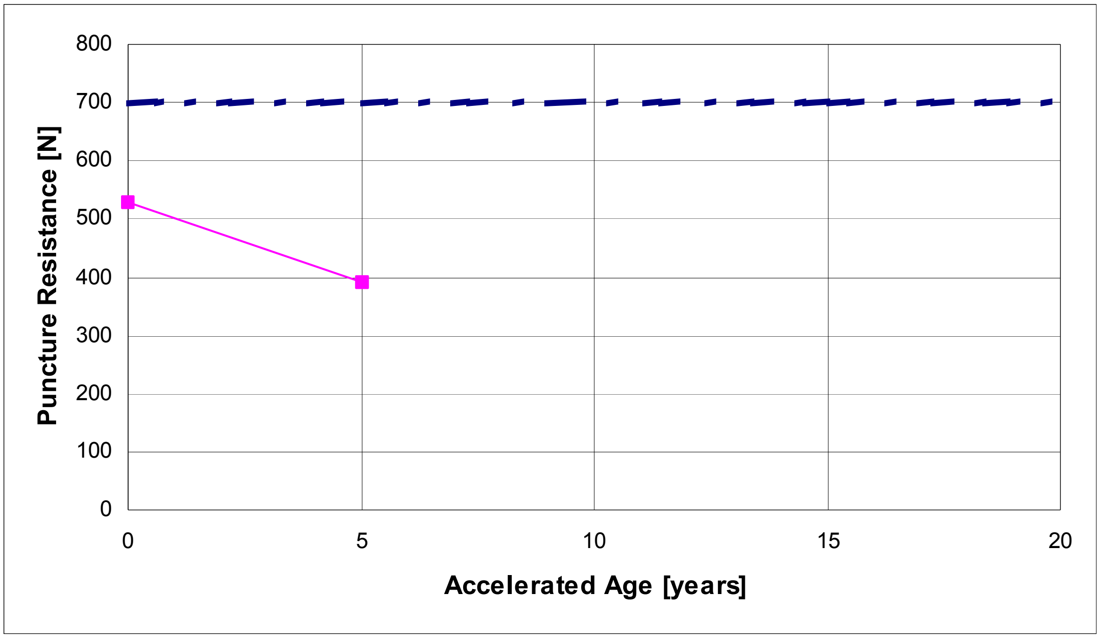

Figure 6.37 Rubber: Puncture Resistance v. Accelerated Age

6.3.4 MATERIAL SUMMARY

Salient points of interest concerning the results of the accelerated ageing tests conducted and predicted age at failure are presented in Tables 6.5 – 6.7 below:

Table 6.5 Butyl: Material Property Failure

MATERIAL PROPERTY	PREDICTED AGE AT FAILURE [YEARS]	NOTES
Weight	-	Weight does not change significantly
Breaking Strength	22 – 25	Steady decrease in strength
Tear Strength	22 – 25	Steady decrease in strength
Puncture Resistance	20 – 22	Steady decrease in resistance
Porosity	-	Pass, with no indication of failure age
Flex Cracking	0 – 15	Random failure of test
Cold Flex	15	Pass at year 10, too brittle to test at year 20
Oil Resistance	-	Pass, with no indication of failure age

Table 6.6 Polyurethane: Material Property Failure

MATERIAL PROPERTY	PREDICTED AGE AT FAILURE [YEARS]	NOTES
Weight	-	Weight does not change significantly
Breaking Strength	13 – 16	Steady decrease in strength
Tear Strength	22 – 25	Steady decrease followed by more rapid degradation after 15 years
Puncture Resistance	12 – 15	Steady decrease in resistance, followed by rapid degradation after 12 years
Porosity	12 – 15	Failure between 12 and 15 years
Flex Cracking	0 – 10	Failed porosity after flexing
Cold Flex	15	Pass at year 10, too brittle to test at year 20
Oil Resistance	-	Pass, with no indication of failure age

Table 6.7 Rubber: Material Property Failure

MATERIAL PROPERTY	PREDICTED AGE AT FAILURE [YEARS]	NOTES
Weight	-	Weight does not change significantly
Breaking Strength	2 – 4	Close to failure at year 0
Tear Strength	5 – 10	Decrease in strength at year 5
Puncture Resistance	-	Failed
Porosity	0 – 5	Random failure of test
Flex Cracking	0 – 5	Failed at year 5, too brittle to test at year 10
Cold Flex	-	Not tested
Oil Resistance	-	Pass, with no indication of failure age

As can be seen from tables 6.5 to 6.7 the test results vary quite significantly between materials. With the exception of Flex Cracking[1], Butyl ages well with adequate material properties out past 20 years. Polyurethane, again with the exception of Flex Cracking, has adequate material properties for about 12 years. However, Polyurethane seems to degrade quite quickly in breaking strength, puncture resistance and porosity after this age.

Rubber, in contrast to Butyl or Polyurethane, exhibits poor compliance with the TP-1324 requirements even when the material is new. The rubber sample was marginal in terms of breaking strength and elongation at five years of age and after ten years proved too brittle to be tested for breaking strength and elongation. Puncture resistance fails the test requirements at year zero and degrades further as aging occurs. Rubber in particular did not meet the requirement for porosity after flex cracking at five years of age, and even for no aging (zero years).

[1] As with the material testing described in 6.2.3, the Flex Cracking test resulted in a number of random failures and the incongruence of these results, with the extremely good results in other areas, suggests that TP-1324 may be overly stringent in this respect

6.4 SUMMARY

The findings from this research project can be summarized as follows:

- The historical inspection statistics in Figure 6.6 indicate that the probability of a liferaft being condemned is ~1% below four years of age, climbs to ~10% between four and 16 years and increases rapidly thereafter. The inspection statistics in Figure 6.13 also show that the probability of a critical problem occurring is minimal below four years, increases significantly after four years and peaks at 16 years with an average age for liferafts with critical problems of 13.5 years.
- The data obtained from the data loggers show that the liferafts are typically exposed to temperatures between 0°C and 20°C and to relative humidity of 70-90% for approximately 80% of the time.
- The depot inspections and material tests show that for field-tested liferafts under four years no problems were encountered through the typical inspections and inflation tests. Neither did their material properties degrade significantly over the four-year period, demonstrating a material resilience for at least four years.
- Three liferaft materials, butyl, polyurethane and natural rubber were subjected to accelerating ageing and then tested in accordance with TP-1324. With the exception of rubber, the liferaft materials do not start to fail TP-1324 until material is at least 12 years of age and in most instances not until material is over 15 years of age. Rubber fails TP-1324 mechanical properties e.g. breaking strength and elongation after ten years and does not meet the requirement for porosity at one cycle of ageing (five years) and even for no ageing (0 year).
- It was noted that all materials tested had a problem with porosity resulting from flex cracking. However, this could be an anomaly in TP-1324 requirements rather than an inherent problem with the materials.

All the above evidence indicates few if any problems in the first four years of service. The evidence also indicates that the incidence of liferaft material failure increases between four and 16 years and increases considerably thereafter.

In light of the above results, it is recommended that the current service inspection interval be revised as suggested in Table 6.8. As shown in Figure 6.6 there is a very low probability of a liferaft being condemned before four years of age. Thus, the first inspection could occur after four years of service. As the probability gradually increases between four and 16 years, the inspection frequency could be set at two years. After the 16-year mark, the service interval should decrease further to an inspection every year or consideration should be given to mandatory retiring the liferaft at this age.

Table 6.8 Revised Liferaft Inspection Interval Schedule

PROBABILITY CONDEMNED	AGE (YEARS)	SERVICE INTERVAL
< 1%	0 to 4	4 years
< 10%	4 to 16	2 years
> 10%	16 and up	1 year

Figure 6.13 supports the this revision as the probability of critical problems begins to increase noticeably after four years and peaks at 16 years, reinforcing both a greater inspection interval before four years and an annual inspection, or mandatory retirement of liferaft, after 16 years.

The depot inflation tests and the material tests both indicate that liferafts are relatively problem-free in the first four years of age, supporting the revision, while the accelerated ageing tests show that problems emerge between 12 and 15 years, indicating that the service interval should decrease near this point. These tests provide additional evidence to support the recommendation to extend the liferaft service interval.

7.0 CONCLUSIONS

This research study presents the methodology employed to investigate the impact of extending the liferaft service interval on liferaft reliability. The study analyzed the depot inspection records, collected data on environmental conditions to which liferafts are exposed, performed inflation and material tests on field-tested liferafts, and carried out accelerated ageing and material properties tests. The conclusions are as follows:

- The historical inspection statistics indicate that the probability of a liferaft being condemned is very low (~1%) below four years of age, increasing (~10%) between four and 16 years and increases rapidly thereafter. The statistics also show that the probability of a critical problem occurring is minimal below four years and increases dramatically to a maximum at 16 years, with an average age for liferafts with critical problems of 13.5 years.

- The environmental data recorded by the loggers showed that the liferafts are typically (approximately 80% of the time) exposed to temperatures between 0°C and 20°C and to relative humidity of 70 – 90%.

- The depot inspections show that for field-tested liferafts under four years no problems were encountered through the typical inspections and inflation tests. The material tests showed that the material properties demonstrate a material resilience for at least four years, with no significant degradation over the four-year period.

- Butyl, Polyurethane and Natural Rubber materials were subjected to the accelerated ageing process and subsequently tested against TP-1324. The material properties tests indicate that, with the exception of natural rubber, these materials meet most of the performance requirements of TP-1324 up to three cycles of aging (15 years). Failures do not occur until the material are at least 12 years old and in most instances not until materials are over 15 years of age. Butyl performed the best for all properties evaluated.

- Material properties tests performed on natural rubber indicate that the material fails the porosity test even without aging and the breaking strength and elongation tests after one cycle of aging (five years. As a result this material is not suitable for liferaft construction

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- It was noted that all materials tested after accelerated aging had a problem with porosity resulting from flex cracking at various cycles of accelerated aging. However, this could be an anomaly in TP-1324 requirements rather than an problem inherent to the materials.

All the evidence from the historical inspections, accelerated ageing tests, depot inspections and material tests, indicates few problems if any in the first four years of service. The evidence also indicates that the probability of liferaft problem incidence and failure increases between four and 16 years and increases considerably again after 16 years.

A suggested revision to the current service interval schedule is shown in Table 7.1 based on the above historical inspection statistics. Due to the very low probability of a liferaft being condemned below four years of age, the first inspection could occur after four years of service. As the probability increases between four and 16 years, the inspection frequency could increase to every two years. After the 16-year mark the data suggests liferaft retirement. Alternatively, in lieu of mandatory retirement after 16 years, the liferaft service interval inspection could revert to an annual basis.

Table 7.1 Revised Liferaft Inspection Interval Schedule

PROBABILITY CONDEMNED	AGE (YEARS)	SERVICE INTERVAL
< 1%	0 to 4	4 years
< 10%	4 to 16	2 years
> 10%	16 and up	1 year

The depot inflation tests and the material tests both indicate that liferafts are relatively problem-free in the first four years of age. The accelerated ageing tests show that problems begin between 12 and 15 years, indicating that after 16 years the liferaft should be retired or the liferaft inspected annually.

Revising the inspection interval schedule would reduce the number of required inspections. This would benefit the industry in a number of ways. It would reduce cost and inconvenience to shipowners, which in turn promotes compliance with the regulations. It would also minimize damage associated with servicing liferafts. Marine safety would be enhanced through compliance with the regulations and more reliable liferafts e.g. liferafts would be less likely to be damaged through shipping and repacking.

8.0 RECOMMENDATIONS

A number of recommendations following from the liferaft service interval extension study are suggested below:

- Specific items contained in the liferaft canisters need frequent renewal and replacement. Items associated with the survival pack, such as such as food rations and batteries require replacement, while the inflation cylinders require periodic testing to ensure functionality. However, if the liferaft inspection interval is increased, these components will need to be replaced and serviced either independently or in conjunction with the proposed inspection interval. Currently, items within the survival pack are guaranteed for at least four years, while inflation cylinders undergo hydrostatic testing every five years. One method to accommodate these requirements is to redesign liferafts so that the service pack and the inflation cylinders can be accessed without unpacking the liferaft. An inspection/access hatch could be incorporated into the canister design so that replacement could be performed easily and cheaply, with minimal disruption to the liferaft itself. It would be rational to synchronize ration replacement and cylinder servicing with the proposed Liferaft inspection intervals.

- Liferaft inspection intervals should be revised to reflect the findings contained in this report. Furthermore, a mandatory liferaft retirement age should be considered at the age associated with a high probability of liferaft material properties failure.

- Material properties tests conducted on natural rubber seem to indicate that rubber is not a suitable material for liferaft construction and should not be approved for use in this application.

- The test requirements for flex-cracking porosity in TP-1324 should be re-evaluated to address the uncertainties in the flex-cracking test results.

REFERENCES

[1] Melville Shipping Ltd., “Lifespan and Durability of Inflatable Liferafts”, April 1984.

[2] MGI International Marine Safety Solutions Inc., “Development of a SOLAS Liferaft”, March 1993, Transport Canada Report No. TP 11672E.

[3] International Maritime Organization, "SOLAS, Consolidated Edition, 1992", International Maritime Organization, London, 1992. ISBN 92-801-1294-5.

[4] Transport Canada, “Standards for Life Rafts and Inflatable Rescue Platforms”, Ship Safety Publication # TP 7321E, February 1992.

[5] Transport Canada, “Material Specification for Coated Fabrics Used in the Manufacture of Inflatable Liferafts”, Ship Safety Publication # TP 1324E, February 1992.

[6] P.G. Collins, "Determination of the UV Transmittance of a Liferaft Canister Material", National Research Council Report #B-1016.1, April 1998.

[7] Tessier et al., "Liferaft Material Properties Test Report", Centre for Textile Technologies, August 2003.

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Yorke-Robinson, A. (Greengate Polymer Coatings Ltd.), “Polymer Coated Fabrics for use in Inflatable liferafts”, International Conference on Marine Survival Craft – Liferafts, Lifeboats, Survival Systems, Royal Institute of Naval Architects (RINA), November 1983.

APPENDIX A

MATERIAL SPECIFICATION FOR INFLATABLE LIFERAFTS (TP 1324E)

TP-1324	Test	COATED SINGLE SIDE	COATED BOTH SIDES	SANDWICH CONSTRUCTION
3.2	***Buoyancy Tubes, Inflatable Supports for Canopies, Boarding Ramps and Floors***			
3.2.1	Weight	Weight < 530 [g/m^3]	Weight < 655 [g/m^3]	
		Variation of weight of coated fabric <= 10%		
3.2.2	Breaking Strength	Minimum breaking strength of 2400 [N] per 50 [mm] of width in warp direction Minimum breaking strength of 2000 [n] per 50 [mm] of width in weft direction		
3.2.3	Elongation at Break	Maximum elongation at break in warp and weft directions is 35% over a 200 [mm] gauge length		
3.2.4	Tear Strength	Minimum tear strength of 1000 [N] in the warp direction Minimum tear strength of 900 [N] in the weft direction		
3.2.5	Puncture Resistance	Minimum puncture resistance of 700 [N]		
3.2.6	Adhesion	Minimum strength between coating and fabric or between plies (sandwich) of 28 [N]/10 [mm]		
3.2.7	Porosity	For each side of reversible fabrics, at 30 [kPa] leakage rate < 15 bubbles in 5 minutes (<5 sites) For non-reversible fabrics, only air holding side need be tested.		
3.2.8	Flex Cracking	After 200,000 flexes, no cracking or de-lamination visible at magnification of 5x.		After 200,000 flexes each side, porosity test at 30 [kPa] shall not exceed 2 bubbles in 10 minutes.
3.2.9	Low Temperature Flexing	After being tested at -50^{o}C the material shall show no visible cracks when inspected at 5x magnification.		After low temperature flex test, porosity test at 30 [kPa] shall not exceed 2 bubbles in 10 minutes. Test to applied to each face of material.
3.2.10	Oil Resistance	After outer surface exposed to ASTM No. 1 oil for two hours at 20^{o}C +/-2^{o}C, there shall be no separation of proofing from the textile. There shall be no residual tackiness when two exposed faces are pressed together, and the proofing shall not smear when rubbed with a single pass of the finger.		
3.2.11	Dimensional Stability	After exposure to a temperature of 70^{o}C +/-1^{o}C for 7 days, after conditioning, the change in dimensions of specimen shall not exceed +/-2%		
3.2.12	Ocean Water Resistance	After immersion in saltwater (salinity between 32 and 36 [gm]/[kg] at a temperature of 20^{o}C +/-2^{o}C, test specimens shall be free from separation of proofing from fabric, and from cracks and tackiness.		After low temperature flex test, porosity test at 30 [kPa] shall not exceed 2 bubbles in 10 minutes. Test to applied to each face of material.
3.2.13	State of Cure	After application of 3 to 4 drops of xylene and standing for one minute, the liquid should spread rapidly and be quickly absorbed leaving a velvety surface, proofing should not become tacky to a finger pressed on it.		Not applicable
3.2.14	Ozone Resistance	After exposure for 8 hours in an ozone chamber to an ozone concentration of 50 [pphm] at a temperature 20^{o}C +/-2^{o}C, no significant cracking should be observed by the naked eye.		After ozone exposure to each side, porosity test at 30 [kPa] shall not exceed 2 bubbles in 10 minutes. Test to applied to each face of material
3.2.15	Freeze/Thaw Cycling	After being subjected to folding test, the coated fabric shall show no evidence of cracking, separations, stickiness or brittleness.		
		Breaking strength in both warp and weft directions shall vary by no more than 10%		
		Elongation at break in both warp and weft directions shall vary by no more than 10%		
		Tear strength in both warp and weft directions shall vary by no more than 10%		
		Adhesion between fabric and proofing in both warp and weft directions shall be >= 90% of that obtained on the "as received" fabric		
		Coated fabric shall emit a maximum of 15 bubbles in 5 minutes from a maximum of 5 site when subjected to porosity test at 30 [kPa]		

TP-1324	Test	COATED SINGLE SIDE	COATED BOTH SIDES	SANDWICH CONSTRUCTION
3.3	***Material Requirements for Outer Canopies***			
3.3.1	Weight	Weight < 200 [g/m^3]		Weight < 275 [g/m^3]
		Variation of weight of coated fabric <= 10%		
3.3.2	Breaking Strength	Minimum breaking strength of 950 [N] per 50 [mm] of width in both warp and weft directions		
3.3.3	Elongation at Break	Maximum elongation at break in warp and weft directions is 35% over a 200 [mm] gauge length		
3.3.4	Tear Strength	Minimum tear strength of 400 [N] in both the warp and weft directions (wounded test method)		
3.3.5	Adhesion	Minimum adhesion between proofing and basic material shall be 10 [N] per 10 [mm] in both the warp and weft directions.		
3.3.6	Low Temperature Flexing	After being tested at -50ºC +/- 2ºC the material shall show no visible cracks when inspected at 5x magnification. Test to be independently applied to each face of the coated fabric if both sides coated.		
3.3.7	Freeze/Thaw Cycling	After being subjected to folding test, the coated fabric shall show no evidence of cracking, separations, stickiness or brittleness.		
		Breaking strength in both warp and weft directions shall vary by no more than 10%		
		Elongation at break in both warp and weft directions shall vary by no more than 10%		
		Tear strength in both warp and weft directions shall vary by no more than 10%		
		Adhesion between fabric and proofing in both warp and weft directions shall be >= 90% of that obtained on the “as received” fabric		
		Coated fabric shall emit a maximum of 15 bubbles in 5 minutes from a maximum of 5 site when subjected to porosity test at 30 [kPa]		
3.3.8	Waterproofness	No water shall pass through within 30 minutes. The coated fabric shall not contain any material that is known to be injurious to a survivor drinking rain water collected from the canopy.		
3.3.9	Colourfastness to Light	The material shall be exposed to continuous Xenon-Arc radiation to the corresponding AATCC Fading Units of an AATCC Blue Wool Standard L6. The material shall be rated on the AATCC grey scale for evaluating change in colour (ISO 105-B02). The maximum allowed colour change after the exposure period shall be grey scale rating of 3.0		
3.4	***Material Requirements for Inner Canopies***			
3.4.1	Weight	Material must be either a close weave construction or have a low porosity to air		
		If fabric is a proofed fabric, weight <= 145 [g/m^2], variation of weight of coated fabric <= 10%		
3.4.2	Breaking Strength	Minimum breaking strength of 500 [N] per 50 [mm] of width in both warp and weft directions		
3.4.3	Elongation at Break	Maximum elongation at break in warp and weft directions is 35% over a 200 [mm] gauge length		
3.4.4	Tear Strength	Minimum tear strength of 140 [N] in both the warp and weft directions (wounded test method)		
3.4.5	Adhesion	If proofed fabric is used, minimum adhesion between proofing and basic material shall be 10 [N] per 10 [mm] in both the warp and weft directions.		
3.4.6	Colour	Material shall be a relatively light shade of neutral colour, such as light grey, that shall not enhance glare within the raft.		

Note:
AATCC – American Association of Textile Chemists and Colourists
ISO 105-B02 – International Standards Organization : Tests for Colour Fastness of Textiles

APPENDIX B

MELVILLE REPORT FINDINGS

DEPOT	QUESTION				
	A	B	C	D	E
1	not much today as compared with a few years ago	no	very little	no but deterioration of fabric in vicinity is often noted	No
2	infrequent occurrence with storage on board ship, more frequently with transport between depot and ship	yes, mostly due to container damage	yes, in some cases where the liferaft had not been inspected when due	no, not with the Beaufort type in this area, to my knowledge	No
3	frequent, if we count minor damage	very hard to tell because if container is badly damaged, the water has a way out	no, by our experience, the fabric should show ability to stand water	no	No
4	infrequent	yes	yes, in older cotton rafts	no	No
5	damage to container is very minimal and infrequent; most damage occurs in the handling of rafts between the depot and the ship	the sealing method on containers is not waterproof and does allow water to seep into containers	some fabric deterioration as a result of (B), especially in older rafts	no	No
6	infrequent	about 10% show evidence of ingress of water	no	no	No
7	occasional damage	yes, where container cracked	yes	no, except for rusting CO_2 bottles	No
8	infrequent	some	yes, where water has penetrated, also rusting of CO_2 bottles	generally, no	No
9	frequent, mostly damaged in transit	not much	little	corrosion of operating head	No
10	often damage in transit	only in a few cases	very little	only rusting of CO_2 bottles	No
11	yes, container stowed too loose in cradle cracks the gel-coat, and ribs are damaged by dropping	about 25% by container damage, 5% by bad stowage	yes, copper oxidization, corrosion on brass fittings, also fungal attack on cotton based liferafts still in existence	not really	No

Questions:
A – Container damage: is this a frequent or infrequent occurrence?
B – Havyou observed evidence of ingress of water due to container damage or method of sealing?
C – Have there been signs of fabric deterioration and/or component damage as a result of (B)?
D – Is corrosion of inflation components a problem?
E – Have there been many instances of component failure?

Source: Melville Shipping Ltd., “Life Span and Durability of Inflatable Liferafts”, April 1984.

DEPOT	QUESTION				
	F	G	H	I	J
1	no	few but increase in failures of porosity test	few	no	500-600
2	there are some remote cases, however, the Beaufort type are protected by an inner valise	60-70% of manometer failures are due to porosity, with older liferafts 30% are due to fabric damage due to misuse or removing or loading onboard ship	the replacement of basic equipment would be nil, providing liferaft is inspected when due	no, the refilling depot in this area has a very good record of recharging CO_2 cylinders	350-400
3	no	manometer test failure due to fabric occurs less than 1%, no relation to date of manufacture	5%	less than 1%	1200
4	no	older rafts show pinholes and fail test	none	no	100-200
5	no	approx. 25% fail manometer porosity test due to the age of the raft; approx. 5% require repair due to damage	we replace the odd flashlight due to rust and corrosion; new plastic flashlights are replacing the old metal type	we have had two instances of incorrect filling in twenty years of operation	800
6	no	about 1%	none	no	50
7	no	very few	very little	no	600
8	no	few since 1966, failures mostly cotton based	no	no	500
9	no	very few	negligible	no	200-250
10	no	very few- mostly cotton based type, older types, a few more rafts than usual have been failing porosity tests	none	no	230
11	no, because plastic is used as a barrier between liferaft and container	very few fail normal manometer test, some fail new Canadian test of 4 psi on over ten year old liferafts, possibly because of overstretch	none	no	250

Questions:
F – Has any fabric damage attributable to vibration been noted?
G – What percentage of manometer test failures has occurred? Can they be related to date of manufacture? What percentage require repair due to damage or deterioration?
H – Other than items required to be repaired by regulation, what is the incidence of failure or replacement of emergency pack items or basic equipment?
I – Have many instances of leakage or incorrect filling of CO_2 bottles been observed?
J – How many inflatable liferafts do you service on average per year?

Source: Melville Shipping Ltd., "Life Span and Durability of Inflatable Liferafts", April 1984.

APPENDIX C

DATA LOGGER TECHNICAL SPECIFICATIONS

Data loggers for this project were supplied by Lakewood Systems Ltd. Each data logger consists of a data recorder box (about 300mm x 170mm x 90mm, model R-X by Lakewood Systems) and a temperature/humidity probe (about 25mm diameter by 300mm, HMP45A by Vaisala).

The Lakewood data recorder box can record time, internal box temperature and 4 external channels. The Vaisala probe required 2 of these external channels to log temperature and humidity. The data loggers were configured to record the following data once per hour (a sampling rate of 1/3600 Hz):

- Time (log start time logged),
- Temperature internal to data recorder box,
- Probe temperature (Channel 1 of 4 external), and
- Probe relative humidity (Channel 2 of 4 external).

The data loggers are battery powered and operate unattended recording data to internal memory until the main battery dies. At one sample per hour, the data logger's main battery can power data recording for about 393.6 days (1.08 years). Each data logger has 32k of onboard memory, and with the channel configuration given, this allowed for storage of approximately 200 days of data. The main battery also charges a small internal "memory battery". This memory battery will keep data stored in memory for about 5 years.

APPENDIX D

ACCELERATED AGEING TEST RESULTS[1]

[1] These test results were taken from a "Liferaft Material Properties Test Report" noted in the References

Accelerated Ageing Test Results - Butyl

BUTYL MATERIAL					0 YEARS	10 YEARS	15 YEARS	20 YEARS
TP 1324	**DESCRIPTION**	**W/F**	**UNITS**	**REQ'D**				
SAMPLE #1								
3.2.1	Weight		[g/m^2]	<=655	500	521	530	520
3.2.2	Breaking Strength	W	[N]	>=2400	5642	4676	4501	3182
		F		>=2000	3896	3303	2771	2566
3.2.3	Elongation @ Break	W	[%]	<=35	35.2	30.6	29.9	23.4
		F		<=35	31.2	28.0	25.2	23.2
3.2.4	Tear Strength	W	[N]	>=1000	2296	1757	1750	1504
		F		>=900	1801	1305	1317	1193
3.2.5	Puncture Resistance		[N]	>=700	1066	884.1	839	658
3.2.7	Porosity		B	<15	0	0	10	3
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	0	0	fail	fail
3.2.9	Cold Flex	cracking	I	none				
		porosity	B	<=2				
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass
SAMPLE #2								
3.2.1	Weight		[g/m^2]	<=655	483	530	515	517
3.2.2	Breaking Strength	W	[N]	>=2400	5673	4747	4615	3961
		F		>=2000	4119	3262	3403	2873
3.2.3	Elongation @ Break	W	[%]	<=35	37.1	29.8	31.3	26.9
		F		<=35	32.8	27.5	27.9	25.0
3.2.4	Tear Strength	W	[N]	>=1000	2309	2038	1964	1767
		F		>=900	1830	1653	1515	1403
3.2.5	Puncture Resistance		[N]	>=700	1024	942	913	794
3.2.7	Porosity		B	<15	0	9	7	1
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	fail	fail	fail	fail
3.2.9	Cold Flex	cracking	I	none		pass		
		porosity	B	<=2		0		
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass

Notes:
W = Warp Direction, F = Weft Direction, B = # Bubbles, I = # Incidents

SAMPLE #3								
3.2.1	Weight		[g/m^2]	<=655	519	534	524	530
3.2.2	Breaking Strength	W	[N]	>=2400	5193	3786	3236	2447
		F		>=2000	3491	3058	2431	1742
3.2.3	Elongation @ Break	W	[%]	<=35	29.5	25.1	23.1	18.1
		F		<=35	27.5	26.5	23.2	18.5
3.2.4	Tear Strength	W	[N]	>=1000	2315	1691	1642	1249
		F		>=900	1755	1355	1191	951
3.2.5	Puncture Resistance		[N]	>=700	1116	783	764	547
3.2.7	Porosity		B	<15	0	0	0	0
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	0	fail	fail	0
3.2.9	Cold Flex	cracking	I	none		pass		
		porosity	B	<=2		0		
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass
AVERAGE OF SAMPLE #1 – SAMPLE #3								
3.2.1	Weight		[g/m^2]	<=655	501	528	523	522
3.2.2	Breaking Strength	W	[N]	>=2400	5503	4403	4117	3197
		F		>=2000	3835	3208	2868	2394
3.2.3	Elongation @ Break	W	[%]	<=35	33.9	28.5	28.1	22.8
		F		<=35	30.5	27.3	25.4	22.2
3.2.4	Tear Strength	W	[N]	>=1000	2307	1829	1785	1507
		F		>=900	1795	1438	1341	1182
`3.2.5	Puncture Resistance		[N]	>=700	1069	870	839	666
3.2.7	Porosity		B	<15	0	3	6	1
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	fail	fail	fail	fail
3.2.9	Cold Flex	cracking	I	none		pass		
		porosity	B	<=2		0		
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass

Notes:
W = Warp Direction, F = Weft Direction, B = # Bubbles, I = # Incidents

Accelerated Ageing Test Results - Polyurethane

POLYURETHANE (PU) MATERIAL					0 YEARS	10 YEARS	15 YEARS	20 YEARS
TP 1324	DESCRIPTION	W/F	UNITS	REQ'D				
SAMPLE #1								
3.2.1	Weight		[g/m^2]	<=655	452	481	475	472
3.2.2	Breaking Strength	W	[N]	>=2400	3771	3293	3317	1904
		F		>=2000	3501	3289	3139	1685
3.2.3	Elongation @ Break	W	[%]	<=35	27.7	26.9	27.0	20.7
		F		<=35	25.4	25.9	25.7	19.8
3.2.4	Tear Strength	W	[N]	>=1000	1791	1623	1721	1538
		F		>=900	1562	1566	1540	1368
3.2.5	Puncture Resistance		[N]	>=700	767	769	701	284
3.2.7	Porosity		B	<15	0	0	0	fail
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	0	fail	fail	fail
3.2.9	Cold Flex	cracking	I	none		pass		
		porosity	B	<=2		0		
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass
SAMPLE #2								
3.2.1	Weight		[g/m^2]	<=655	465	478	469	462
3.2.2	Breaking Strength	W	[N]	>=2400	3767	3172	2224	1568
		F		>=2000	3576	2423	2166	1462
3.2.3	Elongation @ Break	W	[%]	<=35	28.8	25.4	22.4	18.9
		F		<=35	25.3	21.9	20.8	17.1
3.2.4	Tear Strength	W	[N]	>=1000	1790	1521	2056	1140
		F		>=900	1683	1454	1836	1035
3.2.5	Puncture Resistance		[N]	>=700	747	733	307	328
3.2.7	Porosity		B	<15	0	0	fail	fail
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	fail	fail	fail	fail
3.2.9	Cold Flex	cracking	I	none		pass		
		porosity	B	<=2		0		
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass

Notes:
W = Warp Direction, F = Weft Direction, B = # Bubbles, I = # Incidents

Accelerated Ageing Test Results - Polyurethane

POLYURETHANE (PU) MATERIAL					0 YEARS	10 YEARS	15 YEARS	20 YEARS
TP 1324	DESCRIPTION	W/F	UNITS	REQ'D				
SAMPLE #3								
3.2.1	Weight		[g/m²]	<=655	681	692	682	652
3.2.2	Breaking Strength	W	[N]	>=2400	3201	slippage	1471	1052
		F		>=2000	3263	slippage	1201	1038
3.2.3	Elongation @ Break	W	[%]	<=35	20.3	slippage	19.4	14.2
		F		<=35	29.2	slippage	19.1	14.5
3.2.4	Tear Strength	W	[N]	>=1000	1319	slippage	806	653
		F		>=900	1291	slippage	892	694
3.2.5	Puncture Resistance		[N]	>=700	786	244	296	242
3.2.7	Porosity		B	<15	0	fail	fail	fail
3.2.8	Flex Cracking	cracking	I	none	pass	fail	fail	fail
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	fail	fail	fail	fail
3.2.9	Cold Flex	cracking	I	none		pass		
		porosity	B	<=2		fail		
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass
AVERAGE OF SAMPLE #1 – SAMPLE #3								
3.2.1	Weight		[g/m²]	<=655	533	550	542	529
3.2.2	Breaking Strength	W	[N]	>=2400	3580	3233	2337	1508
		F		>=2000	3447	2856	2169	1395
3.2.3	Elongation @ Break	W	[%]	<=35	25.6	26.2	22.9	17.9
		F		<=35	26.6	23.9	21.9	17.1
3.2.4	Tear Strength	W	[N]	>=1000	1633	1572	1528	1110
		F		>=900	1512	1510	1423	1032
3.2.5	Puncture Resistance		[N]	>=700	767	751	435	285
3.2.7	Porosity		B	<15	0	pass	fail	fail
3.2.8	Flex Cracking	cracking	I	none	pass	pass	pass	pass
		delaminate	I	none	pass	pass	pass	pass
		porosity	B	<=2	fail	fail	fail	fail
3.2.9	Cold Flex	cracking	I	none		pass		
		porosity	B	<=2		pass		
3.2.10	Oil Resistance	separation	I	none	pass	pass	pass	pass
		tackiness	I	none	pass	pass	pass	pass

Notes:
W = Warp Direction, F = Weft Direction, B = # Bubbles, I = # Incidents

Accelerated Ageing Test Results - Rubber

RUBBER BASED MATERIAL					0 YEARS	10 YEARS	15 YEARS	20 YEARS
TP 1324	DESCRIPTION	**W/F**	**UNITS**	**REQ'D**				
SAMPLE #1								
3.2.1	Weight		[g/m^2]	<=655	605	648		
3.2.2	Breaking Strength	W	[N]	>=2400	2183	1859		
		F		>=2000	1425	1272		
3.2.3	Elongation @ Break	W	[%]	<=35	28.6	17.6		
		F		<=35	21.7	17.0		
3.2.4	Tear Strength	W	[N]	>=1000	1484	1473		
		F		>=900	1186	1226		
3.2.5	Puncture Resistance		[N]	>=700	428	377		
3.2.7	Porosity		B	<15	0	fail		
3.2.8	Flex Cracking	cracking	I	none	pass	pass		
		delaminate	I	none	pass	pass		
		porosity	B	<=2	0	fail		
3.2.9	Cold Flex	cracking	I	none				
		porosity	B	<=2				
3.2.10	Oil Resistance	separation	I	none	pass	pass		
		tackiness	I	none	pass	pass		
SAMPLE #2								
3.2.1	Weight		[g/m^2]	<=655	605	648		
3.2.2	Breaking Strength	W	[N]	>=2400	2008			
		F		>=2000	1867	1244		
3.2.3	Elongation @ Break	W	[%]	<=35	24.9			
		F		<=35	23.4	17.1		
3.2.4	Tear Strength	W	[N]	>=1000	1465			
		F		>=900	1097	1054		
3.2.5	Puncture Resistance		[N]	>=700	466	380		
3.2.7	Porosity		B	<15	fail	fail		
3.2.8	Flex Cracking	cracking	I	none	pass	pass		
		delaminate	I	none	pass	pass		
		porosity	B	<=2	fail	Fail		
3.2.9	Cold Flex	cracking	I	none				
		porosity	B	<=2				
3.2.10	Oil Resistance	separation	I	none	pass	pass		
		tackiness	I	none	pass	pass		

Notes:
W = Warp Direction, F = Weft Direction, B = # Bubbles, I = # Incidents

Accelerated Ageing Test Results - Rubber

RUBBER BASED MATERIAL					0 YEARS	10 YEARS	15 YEARS	20 YEARS
TP 1324	DESCRIPTION	**W/F**	**UNITS**	**REQ'D**				
SAMPLE #3								
3.2.1	Weight		[g/m^2]	<=655	561	593		
3.2.2	Breaking Strength	W	[N]	>=2400	3733	1763		
		F		>=2000	3462	1900		
3.2.3	Elongation @ Break	W	[%]	<=35	22.8	14.2		
		F		<=35	26.1	19.0		
3.2.4	Tear Strength	W	[N]	>=1000	1466	1387		
		F		>=900	1747	1169		
3.2.5	Puncture Resistance		[N]	>=700	696	418		
3.2.7	Porosity		B	<15				
3.2.8	Flex Cracking	cracking	I	none	pass	pass		
		delaminate	I	none	pass	pass		
		porosity	B	<=2	fail	fail		
3.2.9	Cold Flex	cracking	I	none				
		porosity	B	<=2				
3.2.10	Oil Resistance	separation	I	none	pass	pass		
		tackiness	I	none	pass	pass		
AVERAGE OF SAMPLE #1 – SAMPLE #3								
3.2.1	Weight		[g/m^2]	<=655	590	630		
3.2.2	Breaking Strength	W	[N]	>=2400	2641	1622		
		F		>=2000	2251	1586		
3.2.3	Elongation @ Break	W	[%]	<=35	24.9			
		F		<=35	24.2	18.3		
3.2.4	Tear Strength	W	[N]	>=1000	1472	1305		
		F		>=900	1343	1198		
3.2.5	Puncture Resistance		[N]	>=700	530	392		
3.2.7	Porosity		B	<15		fail		
3.2.8	Flex Cracking	cracking	I	none	pass	fail		
		delaminate	I	none	pass	pass		
		porosity	B	<=2	fail	Fail		
3.2.9	Cold Flex	cracking	I	none				
		porosity	B	<=2				
3.2.10	Oil Resistance	separation	I	none	pass	pass		
		tackiness	I	none	pass	pass		

Notes:
W = Warp Direction, F = Weft Direction, B = # Bubbles, I = # Incidents

APPENDIX E

LIFERAFT INSPECTION DATABASE SYSTEM

LIDS User Guide
Version 1.2

LIDS User Guide
VERSION 1.2

April 2001

MIL Systems

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TABLE OF CONTENTS

SPECIAL NOTE OF THANKS

A special note of thanks is extended to Dunlop Beaufort Canada for providing the Liferaft Inspection Form which served as the base model for this program.

1. SYSTEM REQUIREMENTS

The Liferaft Inspection Database Software (LIDS) operates on any PC using a Windows 9x or Windows NT operating platform. Users should have a basic familiarity with Windows 9x based software products.

2. INSTALLATION

The Liferaft Inspection Database Software (LIDS) version 1.2 is released on a CD. Before installing, close all other programs. To install, use Windows Explorer to view the contents of the CD and double click on the file **LIDS12.msi**. This initiates installation of the LIDS program. This is a standard Windows installation; simply follow the step-by-step instructions that appear on the screen.

If you wish to use a Palm Pilot with this software, as described in Section 6.10, there are several further steps to the installation process:

1. Install the Palm Pilot software (supplied with the Palm Pilot) on your computer.
2. Use Windows Explorer to view the contents of the directory containing the LIDS program files (default directory is **C:\Program Files\LIDS12**).
3. Double click on the file **UCRunSetup.exe** to initiate installation of the **Universal Conduit Runtime Support** (required to download files from a Palm Pilot).
4. Create an ODBC data source name for the LidsPalm.mdb database.
    a. Under the **Start** menu go to **Settings/Control Panel**.
    b. Double click the **Data Servers (ODBC)** icon. The ODBC Data Source Administrator window will open.
    c. Select the **User DSN** tab and click **Add** to open the **Create New Data Source** window.
    d. Select **Microsoft Access Driver (*.mbd)** from the list, and click **Finish** to open the **ODBC Microsoft Access Setup** window.
    e. In the **Data Source Name** field, type LIDS. Under **Database**, click **Select**.
    f. In the **Select Database** window, go to the LIDS program database directory (default directory is **C:\Program Files\LIDS12\database**), and select **LidsPalm.mdb.**
    g. Click **OK** to close the window. Then click **OK** on all remaining windows to complete the process.
5. Return to Windows Explorer to view the contents of the directory containing the LIDS program files (default directory is **C:\Program Files\LIDS12**).
6. Double click the file **conduit.bat** to complete the installation.
7. The HotSync Manager (supplied with your Palm Pilot) must be started after the **conduit.bat** file is run.
   If the HotSync manager was running during the installation, it must now be closed and re-opened.

3. REGISTRATION

Appendix A of this document is a registration form. Please take a few minutes to fill it in and then either mail or fax it to Davie Industries. Registration ensures receipt of any information regarding upgrades to the software.

4. LICENSING

Version 1.2 of the LIDS software is distributed freely by the Transportation Development Centre (TDC). Users to whom this software has been distributed may make back-up copies for archival purposes. However, the software remains the property of the TDC. The software and this publication may not be reproduced, transmitted, transcribed or translated without the written permission of TDC or MIL Systems (Davie Industries).

5. COPYRIGHT AND TRADEMARK NOTICE

Microsoft, Microsoft Explorer, Windows 9x and NT are trademarks of Microsoft Corporation.

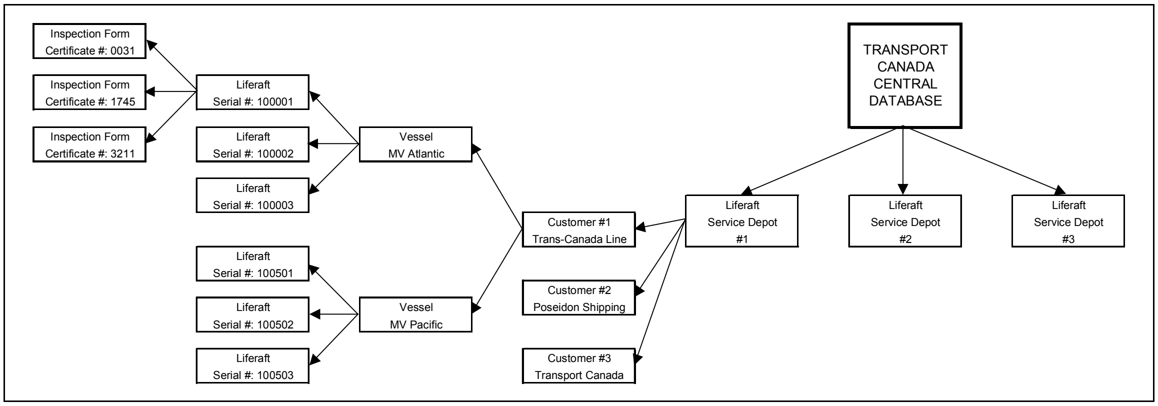
6. INTRODUCTION

The Liferaft Inspection Database Software (LIDS) is a relational database program that generates and archives standard Liferaft Inspection Forms. The program maintains four primary databases:

- Client Database
- Vessel Database
- Liferaft Database
- Inspection Form Database

The relationship between these databases is presented schematically in Figure 1. Each liferaft service depot maintains its set of databases using the LIDS program. Periodically, each service depot submits its database files to Transport Canada, which merges them to form a master database. The master database allows Transport Canada to monitor the service history of each liferaft in service.

Figure 1
LIDS Overview

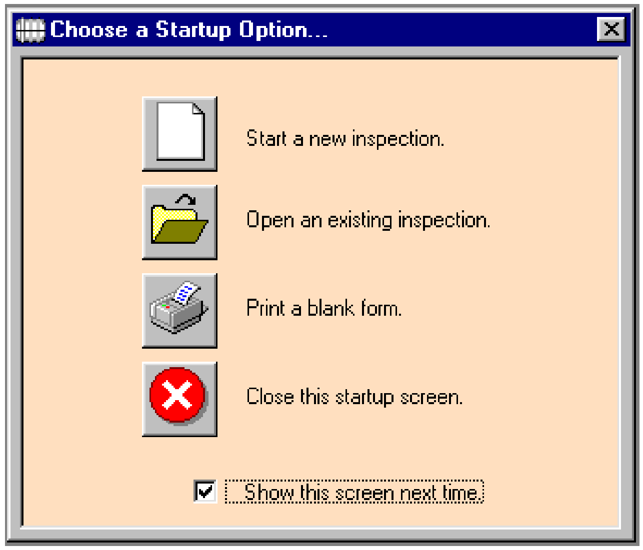


Each service depot defines its clients (customers) in the **Client Database**. Each client may have a number of vessels; these are defined in the **Vessel Catabase** and assigned to a specific client. Each liferaft (unique by serial number) is defined in the **Liferaft Database** and assigned to a specific vessel. Service depot technicians enter their liferaft inspection forms in the **Inspection Form Database**. Completed inspection forms are archived for future reference and may be printed for the appropriate signatures and delivered to the client. Blank survey forms may also be printed for use on the shop floor, the idea being that these would then be passed on to data entry personnel for input to the LIDS database. Data entry is simplified by the relational databases within the LIDS program; information from previously entered clients, vessels and liferafts can automatically load into new inspection forms.

Version 1.2 of LIDS, is experimental. We strongly encourage your written feedback on the program and its usefulness. Of particular interest are suggestions you may have for modifications or updates.

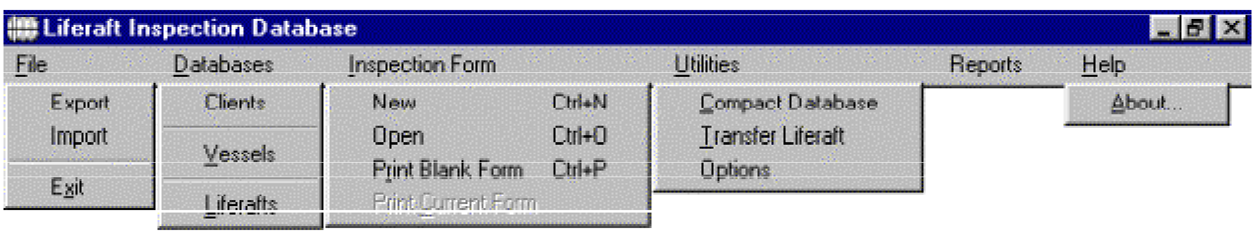
6.1 Start-Up

1. To start the LIDS program, click the **liferaft canister program** icon. The program starts with a splash screen identifying the program version number (this screen is printed on the cover of this manual).
2. After a few seconds, the **Choose a startup Option** window opens, displaying short-cut buttons to common program functions. New users are advised to simply close this window and follow the instructions presented in following sections.
3. To prevent this window from opening the next time you start the program, select the check box at the bottom of the window to deselect the **Show this screen next time** checkbox.



6.2 Main Menus

The LIDS program consists of six menus, shown below. A brief functionality summary of each menu item is provided below. Details are provided in the following sub-sections.



File

Export	Used to create a copy of all database files entered for submission to Transport Canada or for archival purposes.
Import	Used to import an archived database.
Exit	Exits the program.

Database

Clients	Opens the **Client Database** window to add, browse, edit or delete existing client records, delete clients.
Vessels	Opens the **Vessel Database** window to add, browse, edit or delete existing vessel records.
Liferafts	Opens the **Liferaft Database** window to add, browse, edit or delete existing liferaft records.

Inspection Form

New	Opens a window allowing entry of a new inspection form. A client record, vessel record and liferaft record must exist before a new inspection form can be entered.
Open	Opens a window allowing you to select a client. All inspection forms previously entered for that client will be listed. You may select any of these for review and or editing.
Print Blank Form	Prints a blank inspection form.
Print Current Form	Prints the currently displayed inspection form.

Utilities

Compact Database	Compacts the database. This utility should be run periodically to reduce the size of database files.
Transfer Liferaft	Allows reassignment of a previously entered liferaft to a new client and/or vessel.
Options	Allows you to customize the LIDS program for your service depot; company logo, address and names of service technicians. Also allows you to activate or deactivate the **Start-up** window.

Reports

Opens a dialog box that provides the option to print reports on current database.

Help

About	Identifies the LIDS program version number. Also allows you to run a system information check on your computer.

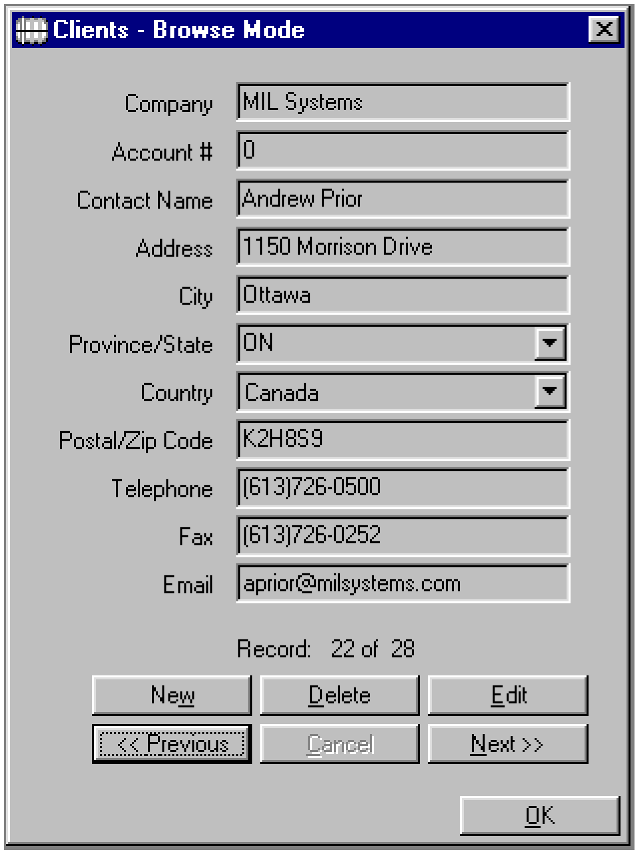
6.3 Client Database

The first step in entering data to the LIDS program is to Enter a client record (a set of client contact information).

Navigating the Client Database

1. Select **Clients** from the **Databases** menu and the following window will open. The **Record: # of #** text field indicates the number of the client records you are currently viewing and the total number of client records in the database.
2. Click the **<< Previous** and **Next >>** buttons to navigate through the client records already entered into the database. If you are currently viewing the first customer in the database, the **<< Previous** button will be inactive; likewise, if you are currently viewing the last customer entered into the database, the **Next >>** button will be inactive.

3. Click **OK** to close the client database window.



Adding a New Client Record

1. Click the **New** button to enter a new client record. The window title will change from **Browse Mode** to **Add Mode**. Note that in the new view, the **New** button is replaced by an **Add** button and the **Cancel** button becomes active. Fill in the various data fields for your new customer and click **Add** to save the information to the database.
2. Click **Cancel** to terminate data entry without saving the information entered. This action returns you to **Browse Mode**.
3. Click **OK** to close the client database window.

Editing an Existing Client Record

1. "Edit" : Click **Edit** to edit an existing client record. The window title changes from **Browse Mode** to **Edit Mode**. Note that the **Edit** button is replaced by a **Save** button and the **Cancel** button is activated.
2. Once you have finished editing information in the various data fields, click **Save** to record your changes.
3. Click **Cancel** to terminate your editing session without saving any changes made. This action returns you to **Browse Mode**.
4. Click **OK** to close the client database window.

Deleting an Existing Client Record

1. Click **Delete** to remove the client currently shown from the database.
2. Click **OK** to close the client database window.

Keyboard Shortcuts

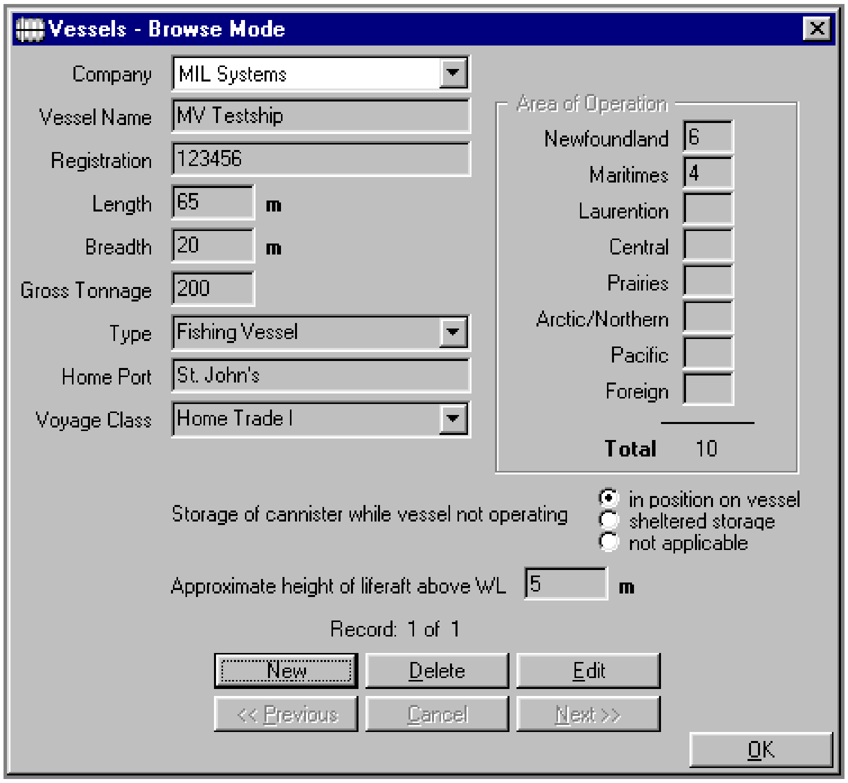
Throughout the LIDS program, keyboard sequences may be used instead of point-and-click mouse control. Most buttons display an underscored letter, holding down the **Alt** key and then pressing the underlined letter key has the same effect is clicking on a button with the mouse. For example, in the customer database window while in **Browse Mode,** holding down the **Alt** key and then pressing the **w** key has the same effect as clicking on the **New** button.

6.4 Vessel Database

The second step in entering data to the LIDS program is to enter a vessel record (set of information about a vessel). Vessels are assigned to a specific client, you must enter the client record before entering information about that client's vessels.

Accessing and Updating the Vessels Database

1. Once the client record has been entered, select **Vessels** from the **Databases** menu and the **Vessels – Browse Mode** view opens.
2. The **Area of Operation** section logs the approximate number of months per year that a vessel operates in various regions. The total cannot exceed 12. However, the total may be less than 12 if the vessel is laid-up for a number of months during the year; it is assumed the vessel will be laid-up at its home port. *This information is of interest to Transport Canada. Please make every effort to ensure that the information entered is as accurate as possible*.
3. Be sure to indicate the storage of liferaft canisters while the vessel is not operating. Click **Not Applicable** if the vessel operates 12 months per year.
4. Note that dimensions requested (**Vessel Length**, **Breadth** and **Approximate Height** of the liferaft position above the waterline) are recorded in meters. *If the information you have gathered is in feet, please convert using the factor 1 foot = 0.3048 meters (multiply feet by 0.3048 to get meters).*



NOTE: Navigation, adding, editing and deleting records follows the same process as described for the client database in Section 6.3. Note that the ***Record: # of #*** *text field here indicates the vessel record information for the selected client only.*

Tracking Unassigned Liferafts

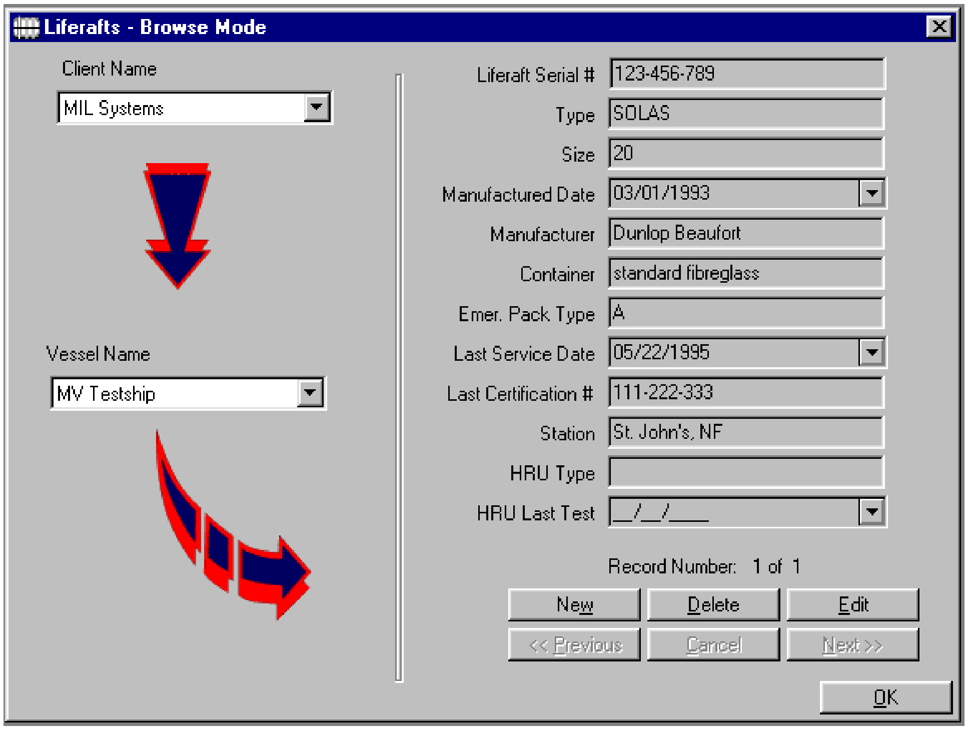
A client may have a number of liferafts that are not assigned to a specific ship. A convenient way to track of these liferafts is to create a ship called “SPARE” and assign these liferafts to that ship.

6.5 Liferaft Database

The third step in entering data to the LIDS program is to enter a liferaft record (set of information about a liferaft). Liferafts are assigned to specific vessels. The vessel record must exist before entering information about that vessel's liferafts (remember vessels are assigned to a specific client, and the client record must exist before a vessel record can be created).

Creating a Liferaft Record

Once the vessel record has been entered, select [Liferafts] from the [Databases] menu and the following window will open.



1. Select a client from the **Client Name** drop-down list.. The Vessel Name drop-down list then displays a list of vessels assigned to that client. The fields in the right side of the interface will allow you access to liferafts that have been assigned to that vessel.

*NOTE: Navigation, adding, editing and deleting records follows the same process as described for the Client Database in Section 6.3. Note that the **Record: # of #** field here indicates the liferaft record information for the selected client and vessel only.*

NOTE: Every liferaft entered into the LIDS database regardless of what client or vessel it is assigned must have a unique serial number. Liferaft records cannot be added, edited saved unless the serial number is unique.

Entering Dates

Entry of dates in the LIDS program is simplified by a drop-down list.

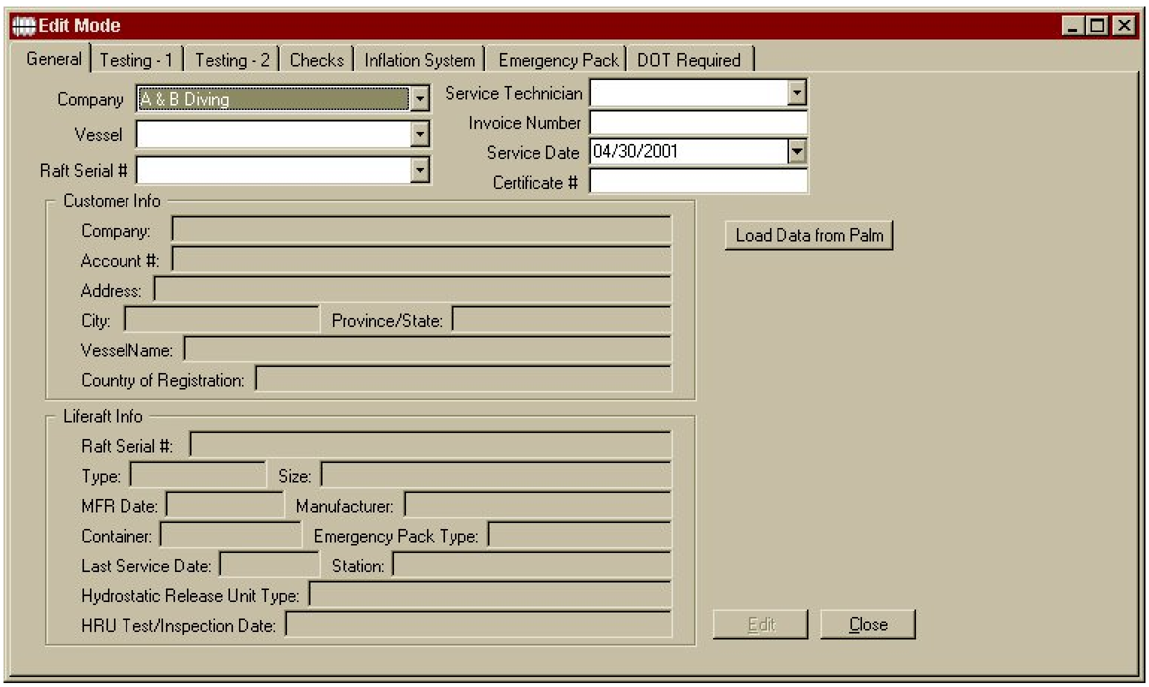
1. Click the down arrow next to the field name. A calendar is displayed.
2. Click on the date you require. The corresponding date is displayed in the field.
3. Use the scroll arrow located at the bottom of the calendar to navigate through various months and years. Alternatively, enter the date (MM/DD/YY) .

6.6 Inspection Forms

NOTE: Be aware that the Client, Vessel Name, Raft Serial #, Invoice # and Certificate # fields that appear on the ***General*** *tab cannot be changed by editing the inspection form once it has been entered. ENSURE THIS DATA IS CORRECT AT THE TIME OF INITIAL DATA ENTRY.*

Creating a new Inspection Form

1. Select **New** from the **Inspection Form** menu. The **Edit Mode** view is displayed. The inspection form consists of seven tabs: **General, Testing-1**, **Testing-2**, **Checks**, **Inflation System**, **Emergency Pack** and **DOT Required**. Each tab provides access to a different section of the inspection form. By default, when you first bring up the inspection form, the **General** tab is displayed. To change tabs, click the tab title you require.



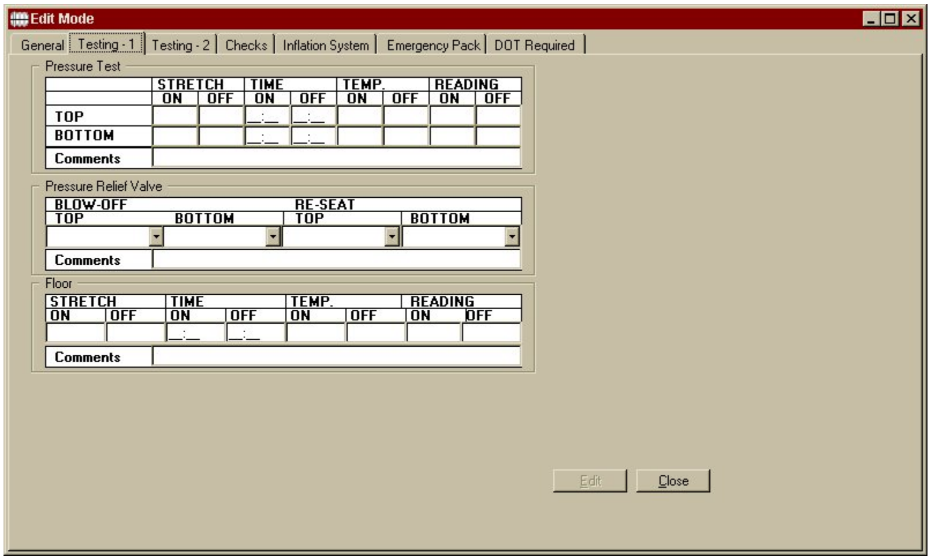
2. From drop-down list in the **General** tab, select a client, vessel and liferaft serial number for the inspection being performed. Once selected, the client and liferaft data fields of the inspection form are automatically populated. *The liferaft MUST be defined in the* ***Liferaft Database*** *before inspection forms can be created.*
3. If the names of the Service Technicians for the depot have been entered into the program through the **Utilities**/**Options** menu (see Section 6.7), the appropriate name may be selected directly from the drop-down menu. If not, ype the name of the **Service Technician** performing the inspection in the data field on the upper right hand side of the **General** tab. .
4. Type the **Invoice #** in the designated field. Ensue that the number is accurate. This field is maintained as a plain text field to allow depots to continue using their current numbering systems. Although this function is not automated, the program verifies whether a given

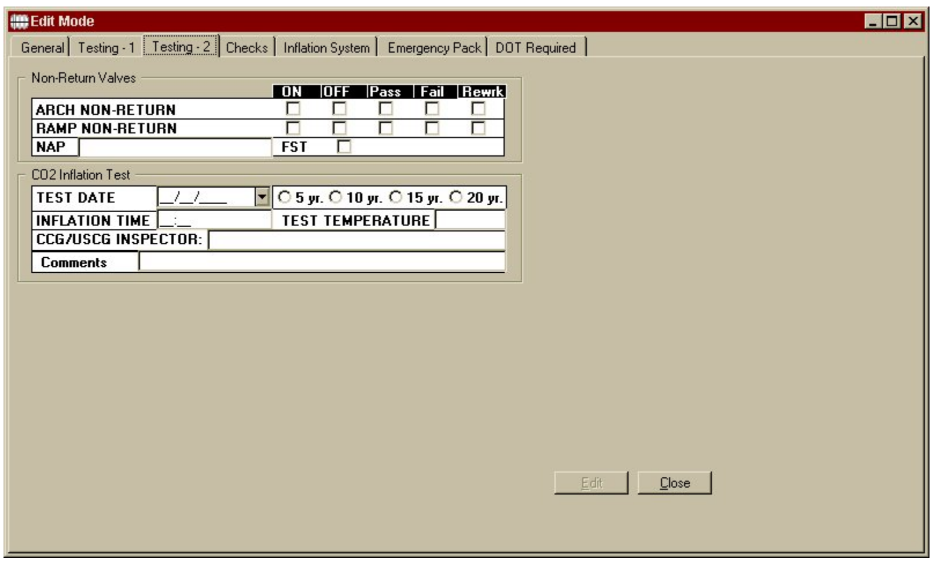
invoice number already exists. It is not possible to save the inspection data if a unique invoice number has not been entered.

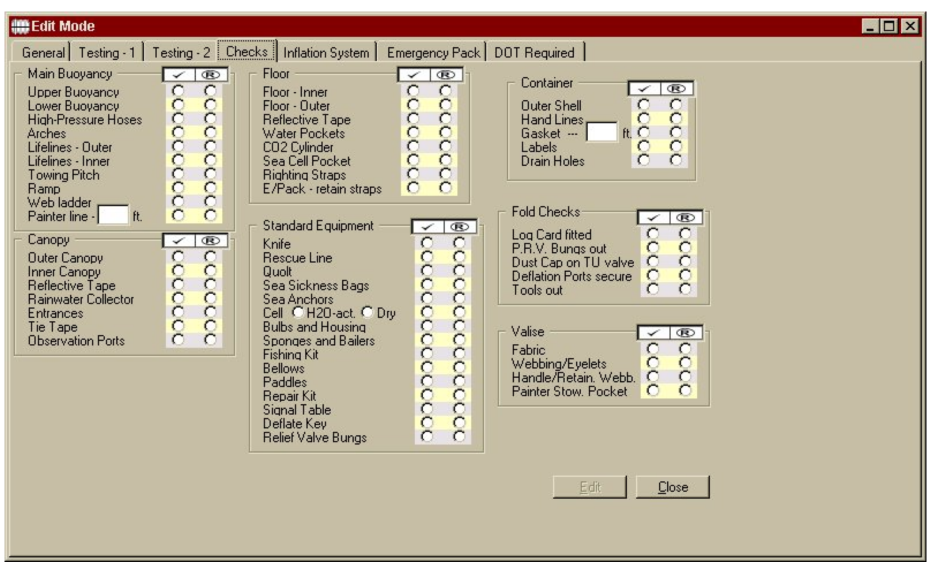
5. Type the **Certificate #** in the designated field.
   a. To automate this function, go to the **Utilities** menu and select **Options.**
   b. Enter a certificate start number in the **Options** view If a starting value is entered as an option, every time a new inspection form is opened, the **Certificate #** will be incremented. If no starting value is entered, this function is not automated (but still verifies whether a given **Certificate #** already exists. *It is not possible to save the inspection data if a unique certificate number has not been entered.*
   NOTE: For a description of the use of the "Load Data from Palm" button, see section 6.10 – Palm Pilot.
6. To continue entering data for the inspection form, click on one of the other tabs at the top of the window.
7. Click C**lose** on the **General** tab will close the inspection form and any changes or additions must be then be made by opening the existing form.

Entering Test Data

1. Select the **Testing-1** tab or **Testing-2** tab to alternate between the two views shown below.
2. Enter the appropriate information regarding various pressure tests performed during the liferaft inspection.
3. Select the **Checks** tab to display the **Checks** view.
   Enter the data realated to basic liferaft inspection checks for M**ain Buoyancy Chamber**, **Canopy**, **Floor**, **Inflation System**, **Standard Equipment**, **Container**, **Fold Checks** and **Valise**. Indicate whether each item in these checklists is ok (✔), needs repair (®) or leave blank if not applicable. Select the appropriate option to the immediate right of the item in the checklist.
4. If ok is indicated, clicking on the needs repair column will move the indicator (filled circle) and vice versa.
5. To deselect an item has been indicated, double click on the filled circle indicator.

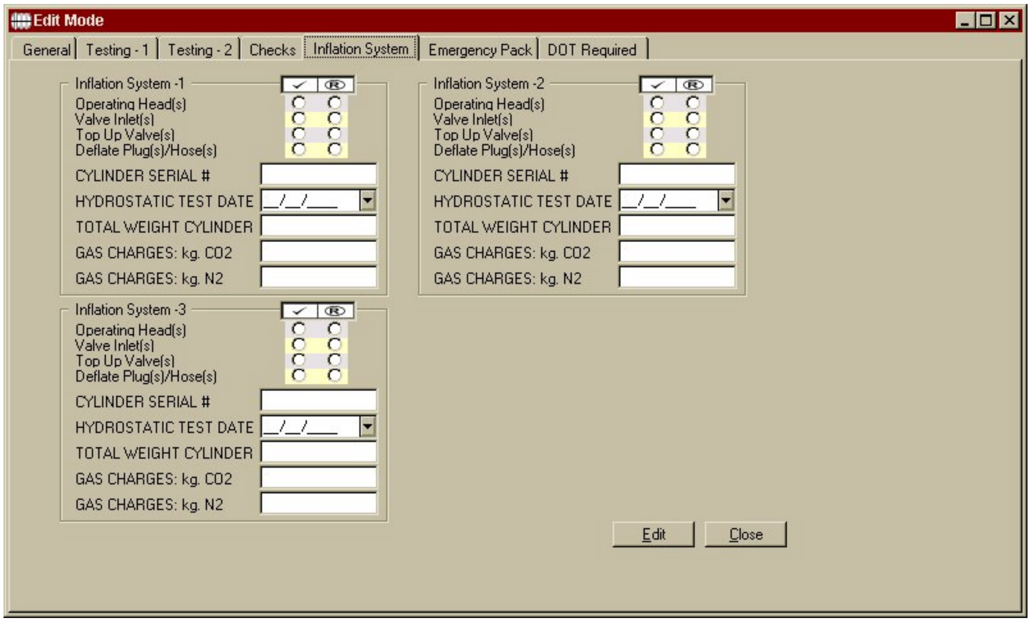

Edit Mode
General
Testing - 1
Testing - 2
Checks
Inflation System
Emergency Pack
DOT Required
Pressure Test
STRETCH
TIME
TEMP.
READING
ON
OFF
TOP
BOTTOM
Comments
Pressure Relief Valve
BLOW-OFF
RE-SEAT
TOP
BOTTOM
Comments
Floor
STRETCH
TIME
TEMP.
READING
ON
OFF
Comments
Edit
Close


Edit Mode
General
Testing - 1
Testing - 2
Checks
Inflation System
Emergency Pack
DOT Required
Non-Return Valves
ON
OFF
Pass
Fail
Rewrk
ARCH NON-RETURN
RAMP NON-RETURN
NAP
FST
CO2 Inflation Test
TEST DATE
5 yr.
10 yr.
15 yr.
20 yr.
INFLATION TIME
TEST TEMPERATURE
CCG/USCG INSPECTOR:
Comments
Edit
Close


Edit Mode
General
Testing - 1
Testing - 2
Checks
Inflation System
Emergency Pack
DOT Required
Main Buoyancy
Upper Buoyancy
Lower Buoyancy
High-Pressure Hoses
Arches
Lifelines - Outer
Lifelines - Inner
Towing Pitch
Ramp
Web ladder
Painter line - ft.
Canopy
Outer Canopy
Inner Canopy
Reflective Tape
Rainwater Collector
Entrances
Tie Tape
Observation Ports
Floor
Floor - Inner
Floor - Outer
Reflective Tape
Water Pockets
CO2 Cylinder
Sea Cell Pocket
Righting Straps
E/Pack - retain straps
Standard Equipment
Knife
Rescue Line
Quoit
Sea Sickness Bags
Sea Anchors
Cell H2O-act. Dry
Bulbs and Housing
Sponges and Bailers
Fishing Kit
Bellows
Paddles
Repair Kit
Signal Table
Deflate Key
Relief Valve Bungs
Container
Outer Shell
Hand Lines
Gasket --- ft.
Labels
Drain Holes
Fold Checks
Log Card fitted
P.R.V. Bungs out
Dust Cap on TU valve
Deflation Ports secure
Tools out
Valise
Fabric
Webbing/Eyelets
Handle/Retain. Webb.
Painter Stow. Pocket
Edit
Close

Entering Inflation System Data

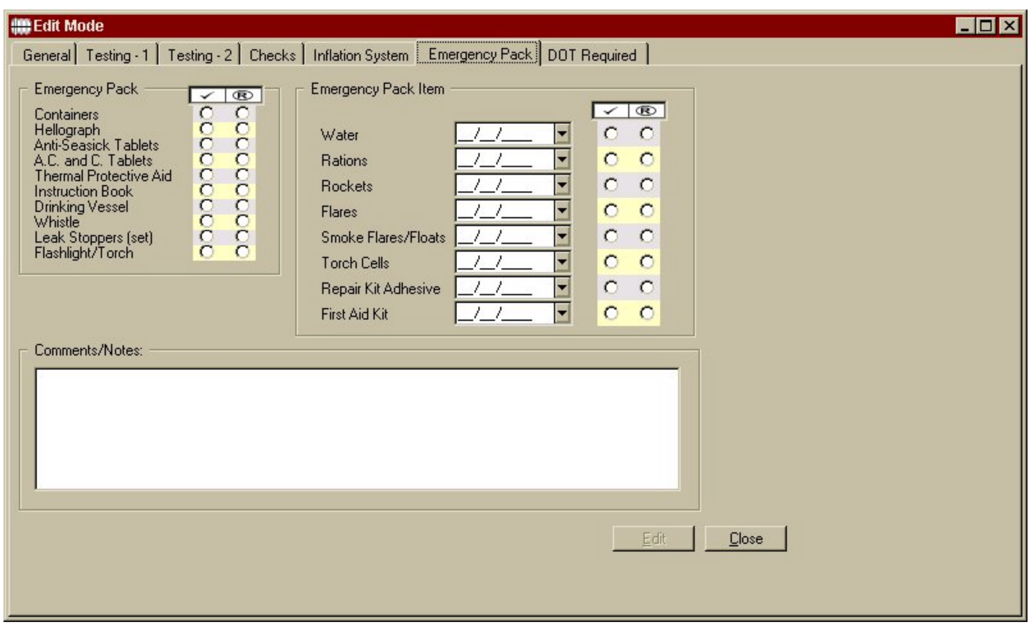
Select the **Inflation System** to view the Inflation System view.



This inspection view is used to check data entry relating to up to three separate inflation systems.

Entering Emergency Pack Data

Select the **Emergency Pack** to enter data for basic inspection checks relating to the liferaft emergency pack.

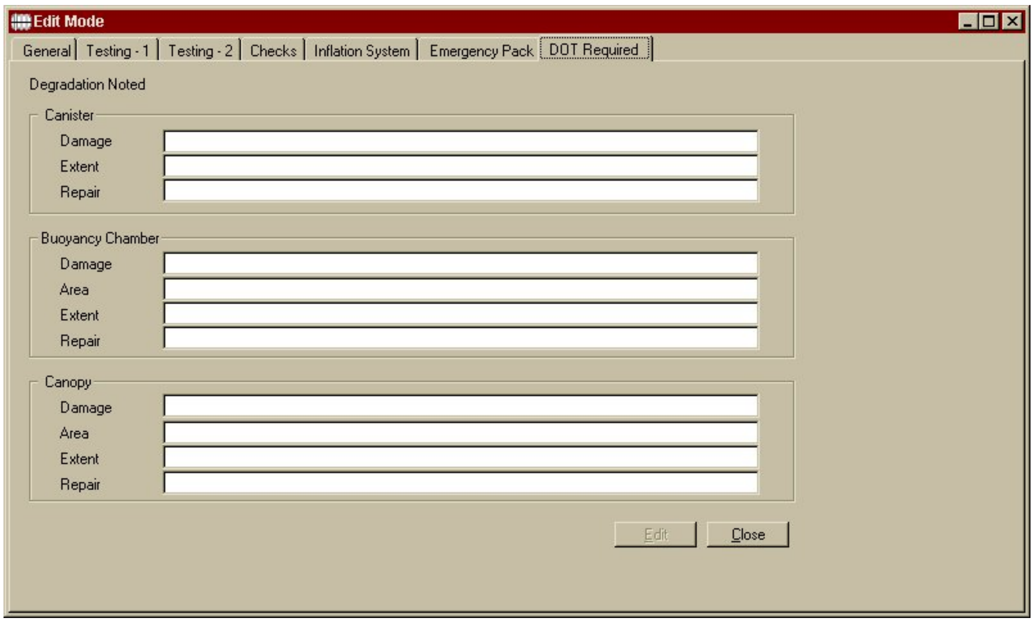


Entering Comments and Notes

The **Comment/Notes** is used for entering text notes regarding the liferaft inspection. Comments should be kept brief, as this field is limited to 255 characters (including blanks).

Entering DOT Data

The final tab on the inspection form is the {DOT Required} tab. This tab provides Transport Canada with data regarding the observed degradation of liferafts throughout their inspection history. Information is requested regarding the observed degradation of various liferaft components including the canister, buoyancy chamber and canopy.

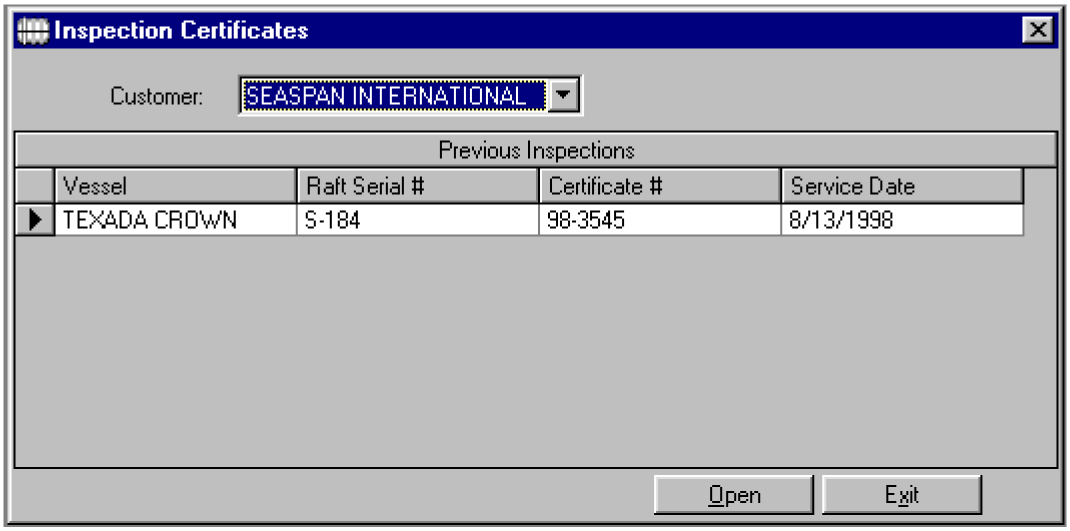


Enter any specific comments relevant to any degradation noted. For example, comments such as "abrasion noted is very localized in the vicinity of the inflation head" or "degradation noted in area that has been previously repaired" should be made here. Please make every effort to enter any relevant comments; the information you provide will be of use to Transport Canada in assessing degradation throughout a liferafts service history.

Viewing Completed Inspection Forms

1. From the **Inspection Forms** menu, select **Open** to access the **Inspection Certificates** view.
2. From the **Customer** drop-down list, select a client from the database. A list of all inspection forms completed for that client are displayed by columns titled: **Vessel**, **Raft Serial #, Certificate #** and **Service Date**).
3. Select the line displaying the inspection form you require. The arrow marker on the left hand side of the window moves to indicate the row you have selected. Click **Open** to view the inspection form.

4. The inspection form is displayed in the same format as it was when it was entered. By default, the inspection form is viewed in **Browse Mode**.
5. If changes are required, click **Edit** to access **Edit Mode**. Make the desired changes and then click the **Close**. A dialog box will ask you to confirm whether you want to save your changes.
   Select **Yes** to save any changes you made; selecting **No** to disregard changes. Either option will close the inspection form window.
6. Select **Cancel** to return to **Browse Mode**.



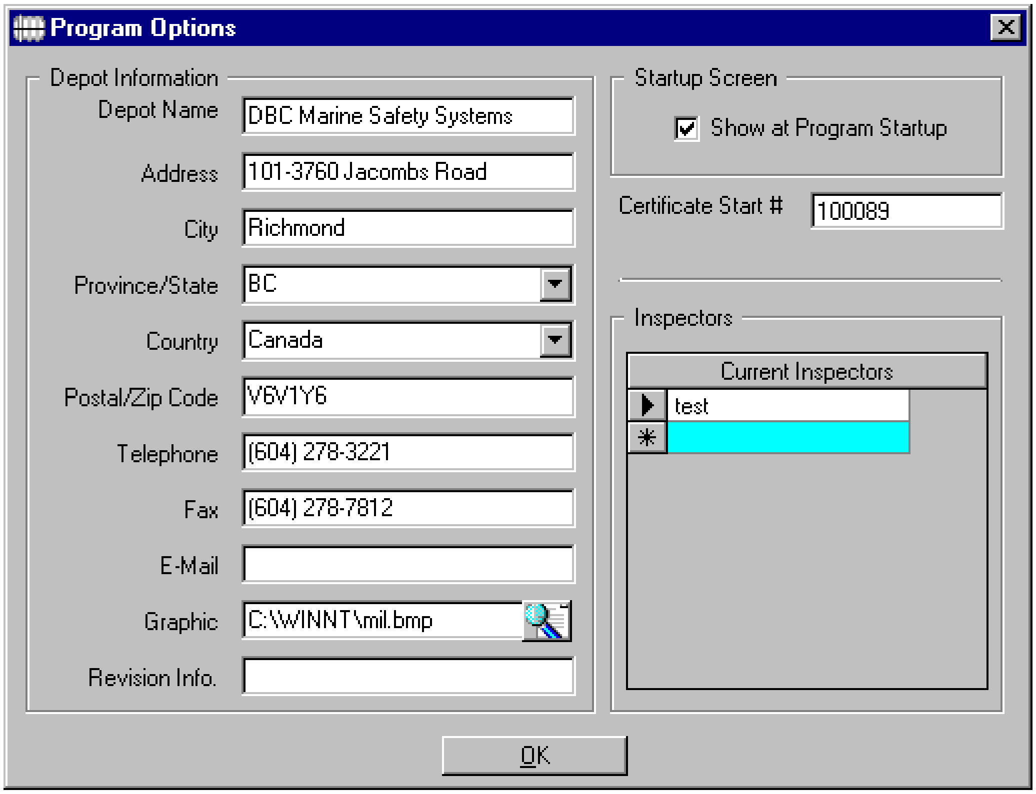
*NOTE: When editing an inspection form, the **Client**, **Vessel Name**, **Raft Serial #, Invoice #** and **Certificate #** fields that appear on the **General** tab cannot be changed.*

Printing

Select **Print Blank Form** from the **Inspection Forms** menu at any time to print a blank inspection form.
During initial inspection, form data entry or while editing an existing inspection form, you can select **Print Current Form**] from the **Inspection Forms** menu to print the inspection form. At all other times, this menu item is deactivated.

6.7 Utilities

The LIDS program allows a certain degree of customization for each service depot. From the **Utilities** menu, elect **Options** to access the Options view. Upon initial installation of the LIDS program, this window is automatically open,prompting for this important information.



The LIDS program allows printing of either completed or blank inspection forms. Appendix A shows an example of the blank inspection form produced. Note that these forms may be customized (Service Depot Name, Address, Tel./Fax. numbers and graphic logo) by entering relevant information in the **Options** view.

Enter a number in the **Certificate Start #** box to have the **Certificate #** on the Inspection Forms incremented, as discussed in section 6.6.

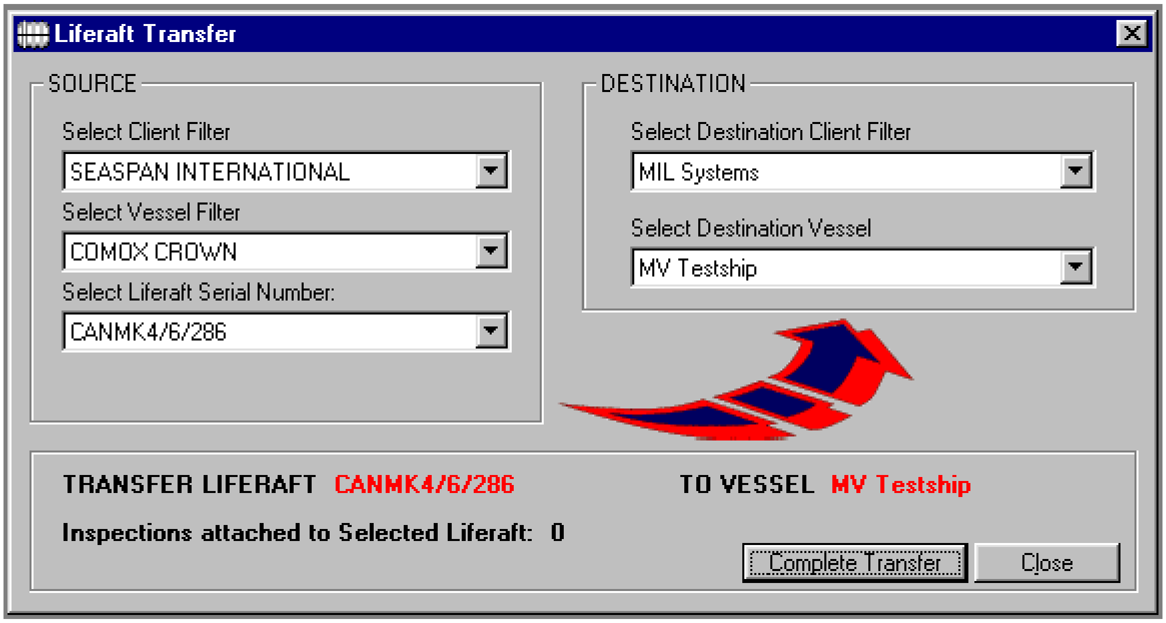
Entering and Deleting Inspectors

1. To enter a new inspector, type the new name beside the asterisk in the inspectors list and press the TAB key on the keyboard.
2. To delete an inspector, select the desired name and press the DEL key on the keyboard. Existing Inspector names are displayed in the drop down box on the inspection form.

Check the "Show at Program Startup" box if you want the startup window to appear when you first run the program (See Section 6.1).

Transfering Utilities

From the **Utilities** menu, select **Transfer**. The **Liferaft Transfer** view is displayed.

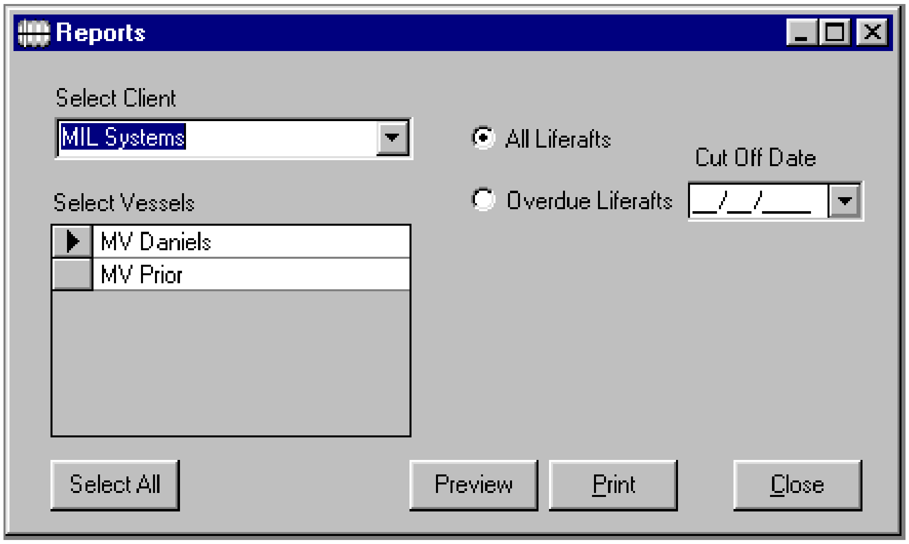


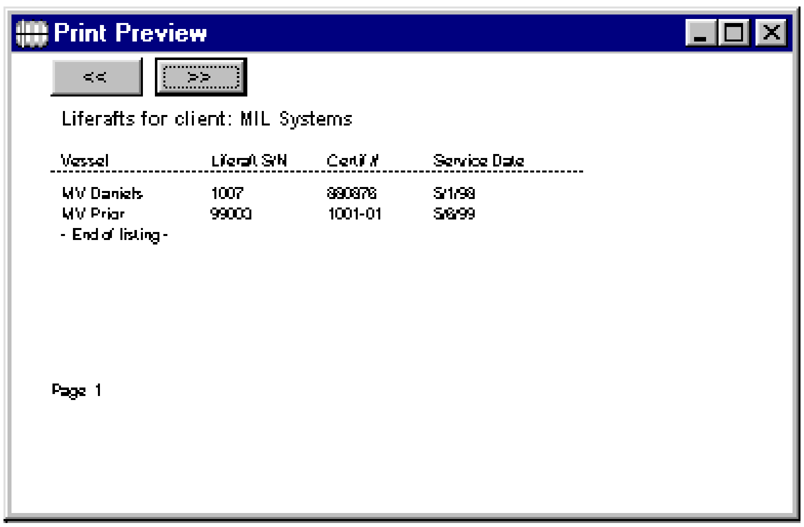
This utility is used to re-assign an existing liferaft from one client and/or vessel to another client and/or vessel. This is most often used to re-assign a given liferaft for one client from one vessel to another.

6.8 Reporting

Producing a Report

1. Select the **Reporting** menu to instantly open the **Reports** dialog box.
2. Select a client from the **Select Client** drop-down list. A list of vessels associated with that client are displayed. Select a vessel(s) by selecting a vessel name(s). Selected vessels are highlighted in blue. Click **Select All** to highlight all vessels listed.
3. Select one of the following reports:
   - **All Liferafts** prepares a report listing all liferafts associated with the vessels selected.
   - **Overdue Liferafts** prepares a report listing only those liferafts associated with the selected vessels whose last inspections were before the entered cut-off date.
4. Select the **Review** button to display the report prepared (see below).
5. Click **Print** button to send this report to your system printer.



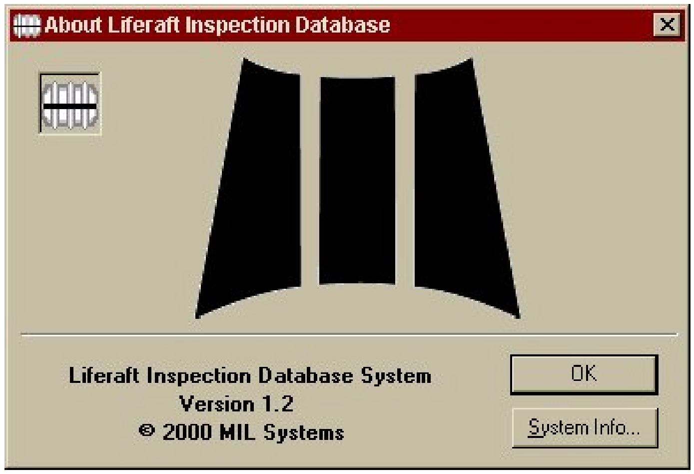


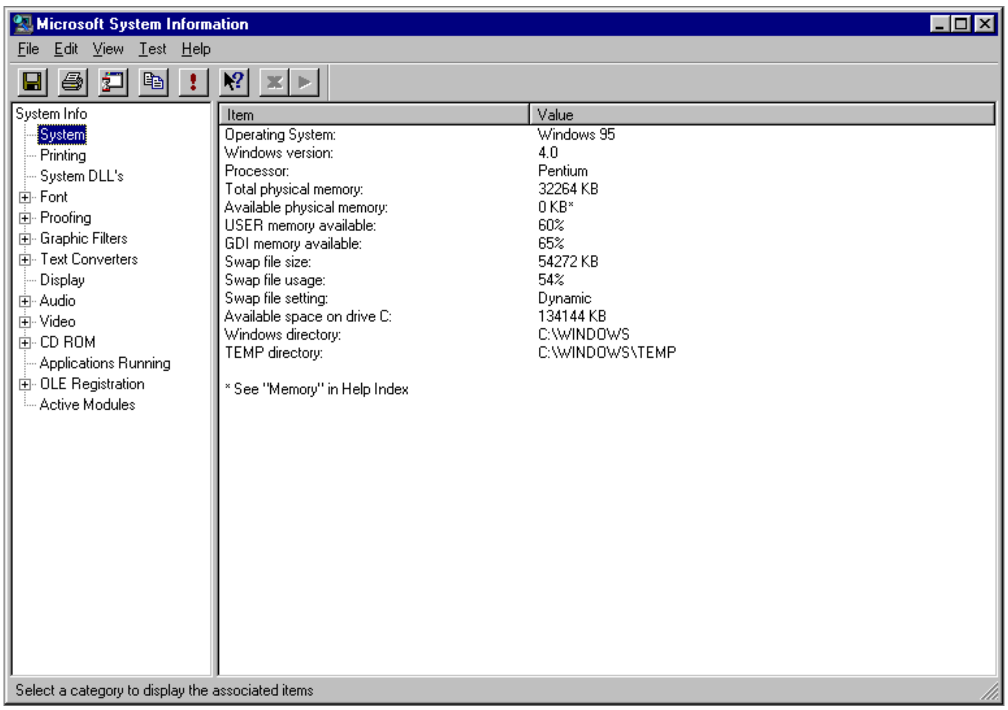
NOTE: Data in the reports generated is derived from the inspection forms entered into the LIDS program.

6.9 Help

Using the Help Files

1. Select **About** from the **Help** menu to open the **About Liferaft Inspection Database** view. This view identifies the version number of the LIDS program you are using.
2. Click **OK** to close the window.
3. Click **System Info...** to obtain basic system information about the computer you are using.





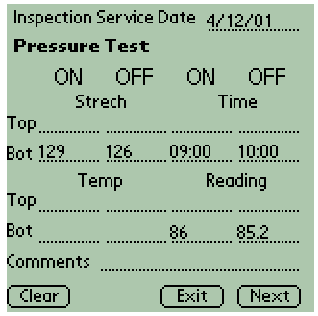
6.10 Palm Pilot

LIDS version 1.2 has Palm Pilot support, which allows technicians to enter inspection data directly on the shop floor. You will require a Palm Pilot IIIc with the LIDS inspection form pre-loaded and a serial interface for this Palm Pilot. The following gives a brief description on using the palm pilot and downloading data to a PC.

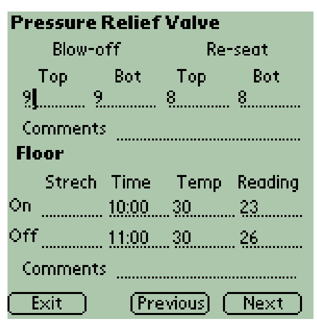
Using a Palm Pilot in conjunction with your PC

1. When the palm pilot is first turned on, the home menu is displayed. To start the program click the **LIDS** icon, which will bring you directly to the first page of the electronic inspection form, as shown below.

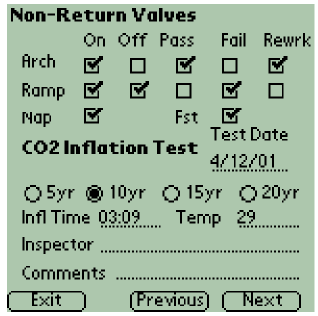
2. At the bottom of each interface, the following buttons are displayed: **Exit**, **Next** and **Previous**. Click **Exit** button to save the data currently entered and close the program. Click **Next** to access the next screen (the **Next** button is not available on the last screen of the program). Click **Previous** brings you back to the previous screen (not available on the first screen).



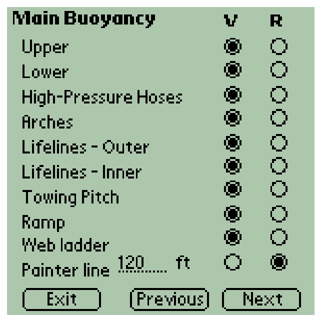
3. The last data saved will be stored in the Palm Pilot until it is cleared. To clear existing data, select the **Clear** button at the bottom right corner of the first screen. You are then prompted to confirm whether you want to clear the data.
4. Select **Yes** to clear the data.
5. The first data entry field is the inspection date. By default this field displays the current date, but this can be modified if required in the following format:MM/DD/YY. The same format is used for all dates entered in the form.
6. The **Pressure Test** form is in the next screen. In this view, fields of **Stretch**, **Time**, **Temp**, and **Reading**. These entries are all numeric. Time values are entered in following format: ##:##. Once all data fields have been completed correctly, click **Next** to navigate to the next screen.



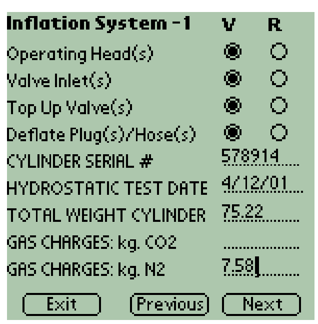
7. The **Pressure Relief Valve** and **Floor** sections of the form are in this view. Enter data in the required format (see above)and click **Next** to access the next screen.



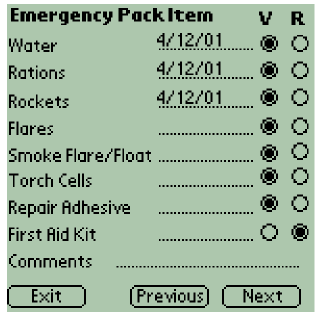
8. This view displays data fields for **Non-Return Valves** and **CO_2 Inflation Test**. Complete the fields for **Non-Return Valves** by clicking the appropriate blank box to activate a check mark.



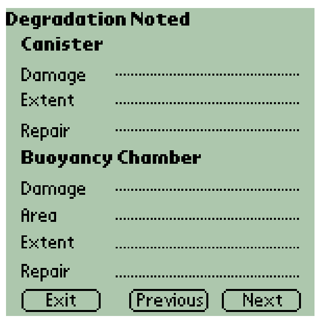
9. Click Next to access the **Main Buoyancy** viewchecklist. The next seven screens of the electronic form include the sections **Main Buoyancy**, **Canopy**, **Floor**, **Standard Equipment**, **Container**, **Fold Checks**, and **Valise**. For each item in each section, select either the **V** or the **R** radio option for each checklist item. **V** indicates that the item was located and found to be in good working order or click on the **R** indicates that the item needs repair.
10. Click **Next** to view the Inflation System-1 screen. This screen is shown above and all fields should be input as previously described.

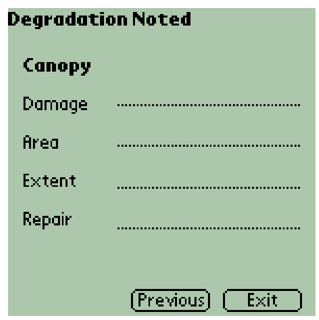


11. The next two screens display **Inflation System-2** and **Inflation System-3**, these allow for the entry of possible additional inflation systems.
12. Click **Next** to access the **Emergency Pack Items** checklist. An expiry date is required for each item in addition to selecting **V** or **R**.



13. The final two screens comprise the **Degradation Noted** section. This is divided into three areas: **Canister**, **Buoyancy Chamber,** and **Canopy**. Text notes can be entered into the fields under each area.





Downloading Data from Palm Pilot to Database

1. Once the electronic form is filled out, the Palm Pilot automatically saves the data. Only one inspection form can be stored at a time on the Palm Pilot.
2. Download the information from the Palm Pilot to the database.
   a. To download the information to the database, place the Palm Pilot in its cradle, and press the **HotSync** button on the case of the cradle. (Note: the cradle must be connected to the computer that is running LIDS 1.2.)
   b. Under the **Inspection Form** menu item, click **New** to open a window allowing entry of a new inspection form.
   c. On the **General** tab, select the **Company**, **Vessel** and **Raft Serial #** from the drop-down lists. Complete the field for **Service Technician** (or select from the list), **Invoice Number**, **Service Date** and **Certificate #.**
   d. Click **Load Data From Palm**. The inspection data from the Palm Pilot is imported into the applicable tabs.
3. Once the data is downloaded, clear it from the Palm Pilot. To clear the data, you must select **Clear** in the bottom right corner of the first screen.
4. You are prompted to confirm your wish to clear the data. Select **Yes** to complete the clearing process.

7. TECHNICAL SUPPORT

All inquiries regarding operation of this software should be forwarded to:

Davie Industries
22 George D. Davie
Levis, Quebec
G8V 6N7

Appendix A
Registration Form

LIDS REGISTRATION FORM

Contact Name:

Company Name:

Address:

Province/State:

Country:

Postal/Zip Code:

Telephone:

Facsimile:

E-mail:

LIDS version #: 1.2

Date:

Please Fax or Mail to:

Andrew Prior
MIL Systems
Suite 200, 1150 Morrison Drive
Ottawa, Ontario
CANADA
K2H 8S9

Fax: 612-726-0252