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FOREWORD

Following concerns arising from the failure of an energy absorbing lanyard in Eire, the Health and Safety Executive's (HSE's) Technology Division (TD) undertook an investigation into the properties, resistance and degradation of man-made fibre lanyards used in energy absorbing lanyards. A number of recommendations were made.

The Report considers the issues surrounding the failure of an energy absorbing lanyard. It gives brief details of the incident in Eire; summarises an HSE test programme; considers information provided by fall arrest equipment designers, manufacturers, suppliers and distributors; reviews several others sources of advice and contacts; lists the requirements of the relevant Standards, EC Directive and Legislation; considers artificial ageing Standards; gives the draft 'Aims' and 'Objectives' of the Personal Safety Manufacturers' Association (PSMA) 'Height and Access Committee'; discusses the findings and makes recommendations; and examines areas for further research.

HSE employs a wide range of qualified and experienced Specialist Inspectors who, in the course of their work, acquire a substantial amount of information and expertise about workplace hazards. Much of this is used in the preparation of official HSE Guidance Notes and formal advice. However, other material which might be less developed could contain useful ideas and be helpful to people involved in health and safety. Such material could also stimulate discussions about problems and their solutions and encourage others to come forward with ideas and practical improvements. Specialist Inspector Reports are designed to publish this material. Any opinions and/or conclusions expressed in this report are those of the author alone and do not necessarily reflect HSE policy.

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EXECUTIVE SUMMARY

Following concerns arising from the failure of an energy absorbing lanyard in Eire, the Health and Safety Executive's (HSE's) Technology Division (TD) undertook an investigation into the properties, resistance and degradation of man-made fibre lanyards used in energy absorbing lanyards. The following recommendations were made:

- Manufacturers should review the longer-term integrity of their product marking, e.g. labels; whether improvements can be made at loops (to reduce abrasion) and whether the "shrink wrapping" of energy absorbers may damage the textile and affect strength.

- Textile equipment requires proper inspection, maintenance (which may include cleaning) and storage. Equipment should be subject to pre-use checks, detailed inspection and (as appropriate) interim inspection by competent persons.

- Frequently used equipment, particularly that used in arduous environments, should be subject to a detailed inspection at least every three months (otherwise, it should be at least every six months). HSE should make available advice to this effect. These intervals are more frequent than generally appears to be current practice.

- BSI Technical Committee PH/5 should request that CEN Technical Committee TC160, as a matter of urgency, confirm that the static test requirement in BS EN 355: 1993 (15 kN) is incorrect (and should be 22 kN). If it is, as seems likely, PH/5 should seek an immediate amendment.

- Any future revision of BS ENs 354 and 355 should include minimum performance requirements for the degradation of man-made textile materials.

- CEN/TC160 should ascertain the extent of, and evaluate, any available information relating to uv-degradation and abrasion of man-made textile materials. Consideration should also be given to the possible future effects of ozone depletion on textile materials.

- Manufacturers should (if they do not currently have appropriate information) undertake further research into the various causes of webbing and rope degradation, particularly of woven and sewn products.

- HSE, in both the short- and medium-term, should undertake research to explore some of the issues that contribute to the degradation of webbing.

- Manufacturers should review the prompt availability of technical support relating to the performance of their yarns, rope and webbing.

- Manufacturers should review the availability and clarity of instructions on the 'obsolescence' and 'lifetime' of their products.

- Manufacturers should, by testing, build up a profile of their own ‘out-of-service’ product(s).

- Manufacturers should, when available for public comment, seek to review the forthcoming revision of BS EN 365.

- Industry (with HSE) should explore ways of promoting an increased awareness of ‘work at height’ issues (‘fall protection’); particularly the training for inspection by competent persons.

1 INTRODUCTION

The purpose of this Report is to consider the issues surrounding the failure of an energy absorbing lanyard. It provides the background to the Report (Section 2) and gives brief details of an incident in Eire (Section 3). It then:

- summarises an HSE test programme (Section 4);
- considers information provided by fall arrest equipment designers, manufacturers, suppliers and distributors (Section 5);
- reviews several others sources of advice (Section 6) and contacts (Section 7);
- lists the requirements of the relevant Standards (Section 8), EC Directive (Section 10) and Legislation (Section 11);
- considers artificial ageing Standards (Section 9);
- gives the draft 'Aims' and 'Objectives' of the Personal Safety Manufacturers' Association (PSMA) 'Height and Access Committee' (Section 12);
- discusses the findings and makes recommendations (Section 13); and
- examines areas for further research (Section 15).

2 BACKGROUND

Following concerns arising from the failure of an energy absorbing lanyard in Eire, the Health and Safety Executive's (HSE's) Technology Division (TD) undertook an investigation into the properties, resistance and degradation of man-made fibre lanyards used in energy absorbing lanyards. The lanyard webbing involved in the fatality [1] was "... in a very poor condition ..." and it appeared that, in the past, it may have been choke-hitched around steelwork.

The investigation covered a number of aspects:

- a review of relevant Standards, and other information;
- a Meeting with eight fall arrest equipment designers, manufacturers, suppliers and distributors, which included a request for technical information;
- follow-up visits and discussions;
- a research program to determine the static tensile strengths and degree of degradation and contamination of forty used energy absorbing lanyards;
- discussions at BSI Technical Committee, PH/5 (with certain issues raised informally with Representatives of CEN Technical Committee, TC/160);
- promotion of safety-related issues by the PSMA 'Height and Access Committee' through support for its new 'Aims and Objectives';
- liaison with the Field Operations Directorate (FOD) Safety Unit, Construction Sector and Safety Policy Directorate (SPD C2: Construction and B4: PPE);
- assessing the need for further research; and
- drafting of a draft TD Minute, subsequently adopted as an Operational Circular (OC).

A detailed 'Sequence of Events' (to 12th March 2001) is presented in Annex A.

[1] *The fatality occurred in Eire and its investigation, etc. was not within HSE's remit, but rather HSA (Dublin).*

3 THE IRISH INCIDENT

The Health and Safety Executive (HSE) does not have written details of the incident that occurred in Eire, but has been given a copy the Test Report [2] on the lanyard involved (produced by the National Engineering Laboratory, NEL). However, whilst the Health and Safety Authority, Eire (HSA) consider possible Enforcement, it is sufficient to know, for the purposes of this investigation, that the energy absorbing lanyard:

- was manufactured from webbing (thought to be in 1996);
- was exhibiting signs that it had, in the past (but not, apparently, during the incident), been choke-hitched;
- failed to deploy, resulting in a fatality (from laboratory testing, the failure load was estimated to be in the order of 2.133 kN);
- exhibited signs of considerable abrasion damage and was in poor condition; and
- did not show signs of any significant corrosive agents (although silica crystals and metallic elements were embedded in the webbing).

In addition:

- the manufacturer's identification was missing; and
- when comparing the product to a recent equivalent, there was a query as to whether the stitch patterns had changed.

[2] *NEL Test Report: 'Tests Carried Out on an Absorbing Lanyard Involved in a Fatal Accident', Project No.: PPE002000, Report No.: 065/2000, Date: February 2000 (HSL Contract Ref. HSLSC187).*

4 TEST PROGRAMME

In response to the concerns expressed, a test programme was undertaken, divided into two parts:

- an investigation into the static strength of the lanyards that had been acquired. This work was undertaken by NEL, under contract to the Health and Safety Laboratory, HSL; and
- an assessment of the condition, and extent of contamination (if any). This work was undertaken by HSL.

Static Strength

NEL is a UKAS approved laboratory and is a Notified Body for the testing of Personal Protective Equipment (PPE) for protection against falls from a height. Their brief was to "... carry out static testing and collection of granular/dust contamination of forty samples of absorber/lanyards removed from service ...". The results are presented in a Report: **"Investigation into the Condition of Webbing Lanyards with Integral Energy Absorbers withdrawn from Service"** (Report No. 230/2000, November 2000).

The results are summarised, in tabular form, in Annex C.

There were thirty-one energy absorbing lanyards made from webbing (ten passed the EN 355 'type test' and twenty-one failed). There were nine energy absorbing lanyards made from rope (six passed, and three failed).

Overall, of the lanyards that failed the results were as follows:

Table 1 Summary of results (failed lanyards)

Failure load (kN)	*Number not passing EN 355 'type test'*
Less than 6 kN	1
6 to 9.99 kN	7
10 to 14.99 kN	13
15 kN and above	3 (not held for three minutes)

Notably, the test programme highlighted that:

- identification labels were missing;
- a number of the lanyards were either assessed as having 'moderate', 'bad' or 'serious' damage (and all failed the static strength performance requirement);
- a number of lanyards assessed as having only 'none/general' or 'slight' damage also failed the static performance requirement;

- the peak load exceeded 6 kN on a large number of occasions, although the average tear-out force was greater than 6 kN in all but one instance [3]; and

- a number of failures were occurring either at the interface loop between the absorber and lanyard, or at a distance of about 25 mm from the absorber/lanyard stitching (possibly due to damage from the protective sleeve around the energy absorber pack).

The Report concluded that "... a major factor on the strength of these products has to be the degree of surface and internal abrasion present in the product as this is a problem which is progressive in nature without the user being overly aware of its presence ...".

It was also noted that "... further testing would be of value with the samples being removed from less reputable sources to judge how much value can be put on correct handling of the product ...", e.g. examination, checks, etc..

Contamination, etc.

The Health and Safety Laboratory is an agency of the Health and Safety Executive. Their brief for the initial examination was to identify and catalogue information from the lanyards supplied; determine the condition of the lanyards with regard to in-service damage and contamination due to operating conditions; and to produce a photographic record of the as-received condition of each lanyard, including any in-service damage observed. The findings of the initial examination are presented in a Report: **"Investigation of Webbing and Rope Lanyards with Integral Energy Absorbers - Part 1, Initial Examination"** (Ref. MM/00/15, Engineering Control Group), dated 1st March 2001.

The Report concluded that "... The majority of the lanyards showed minor wear and abrasion damage ... fourteen lanyards had more extensive areas of wear and abrasion damage, primarily at the absorber/lanyard/connector interfaces ..." and "... the lanyards showed evidence of dirt and dust that may present an additional external/internal wear mechanism ...".

The findings of the contamination and post-test inspections are presented in a Report: **"Investigation of Webbing and Rope Lanyards with Integral Energy Absorbers - Part 2, Final Report"** (Ref. MM/01/03, Engineering Control Group), dated 28th February 2001.

Debris collected from four of the lanyards indicated that most was above 90 microns. When examined visually under an optical microscope, or using a scanning electron microscope, a wide range of elements were observed, including iron, silicon, aluminium, calcium, potassium, oxygen, chlorine and carbon. Typically, particles included fibres, possibly splinters of wood, spherical components and aggregates of smaller particles.

The analysis could not detect chemicals that may have resulted in degradation of the lanyard energy absorbing material. Examination for chemical damage "... is usually hindered by the fact that most chemicals which cause degradation are volatile and do not leave any traceable surface residue ...". The main findings are summarised in Annex D.

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[3] *The 6 kN requirement actually arises from a dynamic performance test requirement (and not the static tests undertaken).*

5 MANUFACTURERS' INFORMATION

Representatives from eight fall arrest equipment designers, manufacturers, suppliers and distributors were requested by the HSE (Annex A) to supply information in response to a number of queries re. lanyard degradation (Annex B). The responses are summarised in Annex H. In addition, five companies (Sala Group, RidgeGear, Pammenter and Petrie, Troll Safety Equipment and Lyon Equipment) supplied additional literature pertinent to these considerations. Relevant extracts are given in the following paragraphs.

Sala Group Ltd.

DBI Sala (Rcd. 20th June 2000, Mr W Cutter) supplied copies of **DuPont Technical Information** [4] Bulletins X-203, 'Light and Weather Resistance of Fibers', April 1966; and X-272, 'Properties of Dupont Industrial Filament Yarns', July 1988.

These Bulletins, the former based on work undertaken for DuPont at the Georgia Institute of Technology, look at the variables affecting the light and weather resistance of fibres (rather than webbing itself) and methods for determining the relative durability. Comparative data on strength retained after outdoor exposure in Florida for periods ranging from 1 to 36 months are presented. The effects of different exposure conditions and fibre characteristics on the outdoor durability for direct and 'under glass' exposures are illustrated [5].

Natural and man-made fibres are degraded by exposure to sunlight and to radiation from other sources. Prolonged exposure causes a loss in breaking strength and adversely affects many other properties of the fibre. Fibre products for outdoor use must have good resistance to sunlight and to deterioration from other causes, e.g. mildew, mould, abrasion, flexing, etc..

The most important factors affecting the light and weather resistance of fibres are the wave length and intensity of the light rays, the general conditions of exposure, and certain characteristics of the fibre product.

Exposure Conditions

There are a number of factors that can account for significant variations in the sunlight and weather resistance of fibre products: geographical location (i.e. distance from the equator and height), season of year (solar radiation varies with the season), weather conditions (e.g. rainfall, smoke and fumes, etc.) and type of exposure (e.g. behind glass).

Types of Light and Weather Durability Tests

Test results from outdoor exposure tests of fibre products show a good correlation with the actual performance of fibre products in outdoor uses. Some organisations frequently use a carbon arc tester to determine the outdoor durability of fibre products. DuPont "... believes that this laboratory test is not an acceptable substitute for outdoor exposure since no consistent correlation either with outdoor exposure tests or with actual weathering performances has been observed by DuPont ...".

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[4] *Also, Bulletin X-225, 'Resistance of Fibers to Bleaching and Stripping Agents', December 1968 (based on work for DuPont at Lowell Technological Institute) contains information on breaking strength after exposure to aqueous solutions of various oxidising and reducing agents.*

[5] *Further details from the DuPont Bulletins, including some typical results, can be found in Annex J of this Report.*

Analysis of the Test Results

It is noted that "... the exposure conditions for Florida outdoor exposure tests are extremely severe because the test items are continuously exposed to sunlight, and to weather elements, for prolonged periods of time. The deterioration observed during such tests is usually many times greater than that experienced during actual use of fibre products ...".

RidgeGear

RidgeGear provided information by reference to **'Tensile Properties of Filament Yarns'** (ICI, Pages 2.22 to 2.27) and **'Chemical Properties of Terylene and ICI Nylon'** (Pages 2.31 to 2.310).

These state that the load extension curve of a yarn gives the best indication of its suitability for a particular end use. The basic curves and figures presented refer to the yarns 'as manufactured' and "... heat treatment, whether by heat-setting (constant length), heat stretching or heat-relaxation processes, can change appreciably the tensile properties, particularly the extensibility and modulus ...". Information is given on creep characteristics, the effect of moisture and temperature, shrinkage properties, abrasion resistance, coefficient of friction and light resistance.

With respect to abrasion resistance it is stated that "... the abrasion resistance of a textile product is not simply a function of the basic properties of the individual yarns; it depends very considerably on the state of presentation of the yarn in the structure of the fabric. Some factors affecting abrasion resistance are: filament diameter, yarn twist and fabric construction. However, for identically constructed fabrics the abrasion resistance of nylon is by far the highest amongst man-made fibres ...".

When considering light resistance it is stated that "... the mechanism of degradation is extremely complicated and the results of accelerated tests are susceptible to misinterpretation because of differences in the spectrum and spectral energy compared with the real life situation. It must be concluded that practical experience is the only true guide. The experience of ICI Fibres over twenty years of development work shows that webbings made from ICI Nylon and Terylene (polyester) have more than adequate resistance to light degradation in any practical situation ...".

The effects of the following agents (or environments) on Terylene and ICI Nylon are given: acids, alkalis, moisture (humidity, water and steam), long-term exposure to heat, oxidising and reducing agents, organic solvents and miscellaneous agents.

UV Degradation Testing - Marling Leek (for RidgeGear) tested two webbing samples under different artificial daylight requirements. The samples were subsequently tested to destruction, with the exposed area in the centre of the test. The results were:

- Test 1 Control Sample (Not exposed) 40.94 kN
- Test 2 HTL, Fakra 5 [6], DIN 75202 29 40 kN
  71.8% Retained
- Test 3 HTL, USA 488 kJ [7], SAE J1885 28.54 kN
  69.7% Retained

Both samples retained breaking loads well in excess of the EN 355 requirement (15 kN) - or even EN 354 (22 kN). However, "... it would be concerning if the original strength was engineered to be only just above the minimum requirements ... also the result could be even worse if the lanyard webbing were thinner and wider than our 51009 webbing which is 2.75 mm thick ... a lot of webbings are seat belt type constructions at only 1.2 mm thickness ...". It was also noted that "... a further consideration is that the uv exposed area was barely visible before I broke the samples. Almost impossible for an end user to notice ..." [8].

Pammenter and Petrie

Pammenter and Petrie supplied a **Shirley Institute Bulletin** (Ref. 'Behaviour of Rope Yarns', Shirley Institute, 1981, 55(1), Pages 2 to 7, FB 1601-76) which notes that "... seawater alone or in combination with other factors had an effect on the physical properties of the rope yarns ...". Two sources of uv were used in the study; one was sunlight through 'Vita glass at Didsbury, Manchester, in the midsummer months, and the other an enclosed carbon arc through a filter of Pyrex glass and water. "... No attempts were made to correlate these two sources since these experiments were designed not to simulate weathering conditions but to find the general effect of uv on the rope yarns ...".

Also, "... the spectral distributions of these two sources of uv are different, but each spectrum contains the important uv wavelengths at which most polymers are degraded, but with different relative intensities. Thus the effect of these two sources of uv can be expected to be similar but the degree of change will be different for different polymers according to the relative intensities of the critical wavelengths in the spectra of the two sources ...".

The results are discussed in detail, with particular reference to mechanical properties, abrasion resistance and structural properties.

In the general conclusions it is noted "... 1. The effect of uv irradiation from whatever source brings about significant changes in the properties of both polyester and polyamide rope yarns. If the irradiation by uv is alternated with treatment with fresh seawater, further changes in properties are recorded ... 3. Although uv irradiation does not affect the mechanical properties of the polyester and polyamide rope yarns, its most significant effect is to lower the abrasion resistance of the yarns to external abradants ... 4. Structural measurements show that the effect of uv irradiation is not confined to the surface of the yarn; there are also changes in the internal structure of the filaments composing the yarn ...".

It is concluded "... the fact that one of the major effects of uv irradiation on yarns is greatly to lower the abrasion resistance to external abradants indicates that the yarns on the surface of a rope

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6 *5 x Fakra equals total exposure time of 5 x 66 hrs = 330 hrs.*

7 *USA 488 kJ equals total light exposure time of 247 hrs (Total duration of test is 313 hrs, because the test includes a dark cycle (3.8 hrs light and 1 hr dark).*

8 *Also, refer to Annex G, 'Results of Tests on RidgeGear Webbing'.*

subjected to such abrasion will be quickly abraded away, exposing underlying yarns to uv irradiation. Ultimately this process must affect the wear-life and also the strength of a rope in an abrasive environment ...”.

The DuPont Information **‘General Properties of Nylon 6.6’** for 1027/N Fibre (Pages 8.9 to 8.15) discusses the long-term effects of ‘hostile’ environments on DuPont nylon yarns. Quantitative indications have been given of changes in fibre properties. It must “... be appreciated that such quantitative information can only indicate the order of magnitude of any change and should not be taken as applying exactly to any specific sample of fibre. Subsequent finishing processes, such as heat setting, can affect the resistance of a fibre to various agencies ...”.

The effect of the acids on Nylon 6.6 is generally severe, although it exhibits high stability in the presence of alkalis. Water has no permanent effect over long periods at normal temperatures. However, the wet strength is 10 to 15% lower than the dry strength due to the absorption of water. The light resistance of products incorporating Nylon 6.6 is affected by a number of factors. Hence, “... a knowledge of the light resistance of basic yarns alone is not sufficient to predict the behaviour of a manufactured item in a practical situation. In general, each type of high tenacity yarn is designed for a particular end use and is engineered to possess the light resistance required for that particular application ...”. The use of Nylon 6.6 is not recommended when using oxidising agents. However, Nylon 6.6 has could resistance to reducing agents [9].

Troll Safety Equipment (Dalloz Fall Protection)

The Troll **‘User’s Guide - Lanyards for Industrial Safety’** states that “... it is difficult to estimate (lifespan) but, as a guide, we advise as follows: do not use more than ten years after date of manufacture or five years after first use, whichever is the sooner. This assumes correct storage. Working life can vary between a single use in extreme circumstances (e.g. highly acidic environment; serious fall) to the maximum of five years, dependent upon how the product is used ...”. The guide gives advice on inspection, maintenance/servicing (inc. cleaning, chemicals, disinfection, lubrication and temperature) and storage. It notes that “... a comprehensive though not exhaustive list is available, on request ...” dealing with chemicals which could affect the performance of the product. It is recommended that “... after any necessary cleaning store unpacked in a cool, dry, dark place away from excessive heat or heat sources, high humidity, sharp edges, corrosives or other possible sources of damage ... do not store wet ...”.

The booklet **‘Tapes, Slings and Harnesses’**, by Dr. Andy Perkins, gives information on the yarns used by Troll.

Nylon

This “... has the best elongation, energy absorption and abrasion resistant properties and therefore it is most suitable for the construction of tapes for the climber. Its detrimental properties are its liability to attack by acids and its comparatively high moisture absorption coupled with distinct loss of strength when wet, though this latter factor is compensated for by increased elasticity ...”.

Polyester

This has a “... high resistance to acids, low stretch properties, low moisture regain and excellent strength retention when wet ... However, it should be realised that if acid is allowed to dry on

[9] An oxidising agent can be defined as a substance that brings about oxidation by giving oxygen to (or removing hydrogen from) another substance; an acceptor of electrons. A reducing agent can be defined as a substance that brings about reduction by removing oxygen from (or giving hydrogen to) another substance; a donor of electrons.

webbing, it will concentrate and damage polyester ... The energy absorption capacity of polyester is generally lower than that of nylon due to its lower elongation properties ... Polyester, therefore, is less safe than nylon where long falls are possible, resulting in high dynamic loads ...".

Weaving

The "... construction method is possibly the most crucial factor affecting abrasion resistance of the web. Essentially, weaving methods can be split into two categories: single and double weft insertion ... Weft insertion is best described as the traditional method of weaving ... it is a slow method of manufacture and consequently the final product is expensive ...". Double weft insertion produces 'knotted edge' tapes. However, in some tapes, if the weft is severed the whole structure will unravel. To guard against this a 'locking thread' on the knitted edge was developed by Troll.

Dyeing

Troll dyes "... are chosen to reduce the effect of ultraviolet (uv) radiation to a minimum. By avoiding fluorescent dyes, for example, which not only fade but also weaken comparatively rapidly, the effect of the dyes on web strength is kept to a minimum ..".

It is stated that "... natural (undyed) tape in 10% stronger than its dyed counterpart and 30% cheaper ...".

Stitching

The "... strength of sewing far exceeds that of knotted joints ...". A sewn joint "... should be stronger than the tape from which the sling is constructed ...".

External Abrasion

The edges of webbing are "... particularly prone to abrasion. If there is a small nick ... tearing failure (is) more likely ... Regardless of width, if there are any nicks visible at all, discard the sling ... Inspect sewn joints regularly ... Losses of 25% are not uncommon, particularly using bar-tacked joints ...".

Internal Abrasion

A "... much insidious phenomenon is internal abrasion where grit penetrates into the internal structure of the weave ...". Extensive testing, sponsored by Troll, was undertaken at Leeds University (Department of Textiles). After exposure in a slurry tumbler "... there can be a rapid fall off to approximately 50% of the tape's original strength, after which it stabilises ...".

Water

If nylon "... is soaked in water, it has a strength loss of between 10% and 20%, although elasticity is greatly increased. Polyester by contrast has poor initial elasticity but is virtually unaffected by the water ...".

Ultraviolet Radiation

Uv radiation can seriously affect nylon climbing equipment. Normal dyed tapes "... can lose up to 4% or more after 300 hours of 'English' summer sun. This loss increases proportionately to the exposure time and the intensity of the sunlight. Prolonged use at altitude, for example, will have a serious effect, with a predicted 50% loss over six months. Tapes with fluorescent dyes are even more severely affected. Finally, the effect of a combination of sea water and uv is very severe ...".

Chemical Damage

This "... is probably the most dangerous form of misuse for both nylon and polyester. If nylon is exposed to acid, then the strength declines rapidly ...". An independent test house states "... In general, the majority of the damage occurred within at the first fifteen minutes. Washing nylon tape which has had acid on it is futile. All nylon gear which has had contact with acid should be discarded, as even the smallest amount of electrolyte can do immense damage. The important thing to note is that very little physical signs of damage were obvious, except for hardening of the web ...". Polyester resists attack by acid "... but if acid is allowed to dry on tape, it concentrates and even polyester can be damaged ... In addition, polyester yarns are damaged by alkaline solutions such as caustic soda ...".

Lyon Equipment

The **'User Instructions'**, provided by Lyon Equipment Ltd., for their energy absorbing lanyard note that "... when stored in dry, chemically inert conditions at normal atmospheric temperatures out of direct light, this product has a lifespan, unused, of at least 5 years. Actual working life may be as low as a single use in extreme conditions ...". The lanyard is "... suitable for use in normal atmospheric conditions (- 20^{o}C to + 50^{o}C) ...". It is recommended that the lanyard be kept clean and dry and that "... dirty components may be washed in a mild detergent, rinsed in clean water and dried naturally away from any heat source ..."

Some **Petzl Technical Information** was also provided. This states "... fibres age naturally in contact with air even if it is not used and stays in a box. In ageing, the strength of the fibres stays more or less the same, but their elasticity diminishes..." and "... the effect of uv light may be more destructive ... It varies depending on the colour of the webbing, and the quality of the anti-uv treatment it has received ... discolouration of the harness is frequently a sign of uv damage to the fibers ...".

The Lyon Equipment Ltd. **'Care of Your Equipment'** Information (Appendix 7) - taken from the Beal website [10] - states that "... brittle or powdery deposits on the (rope) sheath might indicate chemical decomposition ... Ropes should be washed periodically ...".

[10] www.bealropes.com

6 OTHER SOURCES OF ADVICE

During the work, a number of other sources of information relating to webbing, etc. were obtained:

The **'Encyclopaedia of Chemical Technology'**, Volume 10 [11], Pages 539 to 559 (Fibres Survey), presents an overview of fibres and fibre products, introducing the underlying concepts that govern the manufacture and properties of these materials. Textile fibres may be classified according to their origin: naturally occurring fibres, synthetic fibres, and those based on synthetic organic polymers. Natural fibres are those derived directly from the animal, vegetable, and mineral kingdoms. Fibres manufactured from natural organic polymers are regenerated [12] or derivative [13].

Fibres based on synthetic organic polymers, generally referred to synthetic fibres, have revolutionised the textile industry since their initial commercialisation by the chemical industry in 1940. The most widely used synthetic fibres are based on polyamides, polyesters, acrylics, polyolefins, and polyurethanes. Fibre manufacture is based on three methods of fibre formation or spinning. These are melt spinning, dry spinning, and wet spinning. In 'melt spinning' the polymer is heated above its melting point and the molten polymer is forced through a 'spinneret'. In 'dry spinning' the polymer is dissolved in a suitable solvent, and the resultant solution is extruded under pressure through the 'spinneret'. In 'wet spinning' the polymer is also dissolved in a suitable solvent and the solution forced through a 'spinneret' which is submerged in a coagulating bath.

In most instances the filaments formed by melt, dry, or wet spinning are not suitable textile fibres until they have been subjected to one or more successive drawing operations. The fine structure and physical properties of synthetic textile fibres are frequently further modified by a variety of thermomechanical annealing treatments, including processes known as texturing. In the traditional methods of fibre manufacture the filaments are obtained in continuous form. When several such filaments are combined together and slightly twisted to maintain unity, the product so obtained is called a multifilament yarn. A typical yarn may contain 100 single filaments.

Fibres are used in the manufacture of a wide range of products that can generically be referred to as fibrous materials. The properties of such materials are dependent on the properties of the fibres themselves (e.g. the cross-sectional shape of fibres is an important characteristic that influences many end properties) and on the geometric arrangement of the component fibres in the structure. Several types of fibrous materials can be distinguished primarily on the basis of fibre organisation. At one extreme are isotropic assemblies where the fibres are arranged in a completely random fashion with no preferred orientation in any of the three principal spatial axes. Alternatively, and more commonly, there are various anisotropic fibrous materials with the fibres arranged in well-defined spatial patterns.

Textile yarns are produced from staple (finite length) fibres by a combination of processing steps referred to collectively as yarn spinning. Textile yarns are also produced from continuous filament synthetic fibres.

The properties of textile fibres may conveniently be divided into three categories: geometric, physical, and chemical. These are illustrated below:

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[11] Kirk-Othmer 'Encyclopaedia of Chemical Technology', Fourth Edition, Volume 10, Publisher: John Wiley & Sons.

[12] A regenerated fibre is one formed when a natural polymer, or its chemical derivative, is dissolved and extruded as a continuous filament, and the chemical nature of the natural polymer is either retained or regenerated after the fibre formation process.

[13] A derivative fibre is one formed when a chemical derivative of the natural polymer is prepared, dissolved, and extruded as a continuous filament, and the chemical nature of the derivative is retained after the fibre formation process.

Table 2 Properties of textile fibres

Geometric	*Physical*	*Chemical*
Length	Density	Response to acids, etc.
Cross section	Thermal	Sorption
Crimp	Optical	Swelling
	Electrical	
	Surface	
	Mechanical	

The sorption of molecular species other than water from the atmosphere or from solution must also be considered. Paramount among general sorption properties of textile fibres are their dyeing characteristics, which describe the rate and extent of dye sorption. Wash- and lightfastness are also particularly important.

The mechanical properties of fibres, or of any other material, may be described in terms of six factors: strength, elasticity, extensibility, resilience, stiffness and toughness. The resilience of a fibre describes its ability to absorb work or mechanical energy elastically, that is, without undergoing permanent deformation. The elasticity of a fibre describes its ability to return to original dimensions upon release of a deforming stress. Toughness may be quantitatively designated by the work required to rupture the fibre.

DBI Sala **Technical Bulletin No. MISC005, Rev. A "Cleaning of Web Personal Fall Protection Products"** (Mr W Cutter, Corporate Director of Research and Development, Capital Safety Group Ltd.). This gives details for the cleaning processes and procedures which apply to DBI Sala's nylon and polyester webbing products. It is stated that "... Personal fall protection products manufactured from webbing can, and should be, cleaned periodically to help extend the life of the product and maintain an acceptable level of performance ...".

Testing indicates "... that laundering itself does not contribute to strength loss. Although it was observed that commercial washing could cause abrasion between metal hardware components and webbing straps, as well as cause degradation of product markings ...". It is suggested that "... the specific length between laundering is solely dependent on the cleanliness of the product ... some applications may require weekly cleaning: other applications may require the product to be cleaned on an annual basis ...".

It is suggested that "... laundering will be effective on the typical dirt and grease found in many industrial settings. Many paints, tar, and industrial chemicals cannot be completely removed from the webbing. It is recommended that samples be laundered and inspected before a large quantity is processed ...".

Two laundering procedures are detailed (high-pressure power type washers and steam cleaners should be avoided): hand scrubbing and machine wash. Once cleaned, the product should be rinsed in clean water (or in a rinse cycle) and hung to air dry in a well ventilated area out of direct sunlight (never exceed 200^{o}F, when drying).

The technical bulletin suggests that a mild detergent (bleach free) is acceptable - and the product names of acceptable cleaning agents are presented. The pH level (acidity or alkalinity) [14] of the

[14] *Acidity is indicted by a pH level of less than 7; alkalinity is indicated by a level greater than 7 (pH is a unit of measure which describes the degree of acidity or alkalinity of a solution; and is measured on a scale of 0 to 14).*

cleaning solution, for DBI Sala products, should be no higher than 11 or 12 (as this may harm the webbing and effect the performance of the products).

The draft (31st July 2000) of a proposed revision to **EN 365 "PPE and other equipment for protection against falls from a height - General requirements for instructions for use, maintenance, periodical examination, repair, marking and packaging"** [15]. This gives a comprehensive list for: the minimum general requirements for instructions for use; maintenance; periodical examination; marking and packaging of PPE.

There is a definition of a 'competent person', viz. "Designated person who is knowledgeable for the current periodical examination requirements, recommendations and instructions issued by the manufacturer applicable to the relevant component, subsystem or system ... Note 1. This person should be capable of identifying defects, should be responsible for initiating the corrective action to be taken and should have the necessary skills and resources to do so ... Note 2. A competent person may need to be trained by the manufacturer on specific PPE or other equipment, e.g. due to its complexity or innovation, or where safety critical knowledge is needed in the dismantling, reassembly, or assessment of the PPE or other equipment, and may need to have that training updated due to modifications and upgrades ... Note 3. A person may be competent to carry out periodical examinations on one particular model of PPE or other equipment or may be competent to inspect several models."

The 'Information to be supplied by the manufacturer' shall include (Clause 4.1.1.3) instruction on pre-use checks and the expected lifespan of the equipment under normal conditions of use (obsolescence), or how this can be determined. The 'Instructions for maintenance' shall include (Clause 4.1.2) cleaning and storage procedures, including the need to dry naturally.

The 'Instructions for periodical examinations' shall include (Clause 4.1.3) a warning to emphasise the need for regular periodical examination and a recommendation in regard to the frequency of periodical examinations (which should be undertaken by a competent person "... at least every twelve months ...").

Under 'Marking' (Clause 4.3), it is a requirement that "... Each item of PPE shall be clearly, indelibly and permanently marked, labelled or stamped by the manufacturer ...".

Sala **"Fall Prevention and Fall Protection - 12 Basic Principles"** (Draft) [16] includes "... (11) The inspection and maintenance instructions and equipment must be understood and followed ..."; and "... (12) You must be competently trained ...".

The **Canadian Centre for Occupational Health and Safety, "Care of Safety Belts, Harness and Lanyards"** [17] gives advice on the care of safety belts, harnesses and lanyards. It suggests that equipment should be inspected daily and that a trained inspector should examine equipment at least yearly. An indication of what to look for during an inspection is given, e.g. webbing, buckle, rope, hardware, safety strap, etc.. It states that "... basic care prolongs the life of the unit and contributes to

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[15] *The current version of EN 365 is BS EN 365: 1993, 'PPE against falls from a height - General requirements for instructions for use and for marking' (but is limited in the advice that it provides). See BSI Draft For Public Comment, 01/560917DC (26/02/01, PH/5).*

[16] *The first ten principles are: '(1) Gravity never takes a rest'; '(2) It is not the fall that causes the death or injury' (but the sudden stop); '(3) Falling from one level to another is the second most likely cause of serious injury and death at work' (the leaflet was written for the Australian market); '(4) Writing a fall protection plan helps prevent fall-related injuries'; '(5) There is no such thing as a safe distance to fall'; '(6) You must be connected to a structure using your safety line at all times'; '(7) The structure you connect to must be very strong'; (8) A full body harness rated for fall arrest is better than a belt'; '(9) The harness or belt must be fitted and adjusted correctly'; '(10) It's too late to plan a rescue after someone has fallen and they are suspended mid-air'...*

[17] *http://www.ccohs.ca/osanswers/prevention/ppe/belts.html*

performance ...” and that it should be “... stored in a clean, dry area, free of fumes, sunlight or corrosive materials and in such a way that it does not warp or distort the belt ...”.

The **Occupational Safety and Health Administration, US Department of Labor, “Fall Protection”** [18] is part of the Construction Safety and Health Outreach Program (May 1996) and gives the scope and application of the OSHA ‘Construction Industry Safety Standards’, the duty to have fall protection, fall protection systems criteria and practices, protection from falling objects, and training.

The **Industrial Rope Access Trade Association (IRATA) “Guidelines on the use of rope access methods for industrial purposes”** (Edition 2, January 2000). Whilst the investigation was not as a result of an incident in industrial rope access, the IRATA Guidelines (Section 11, ‘Care and maintenance of equipment’) contain useful general advice on the use, care and maintenance of textile equipment, e.g. ropes, webbing, harnesses, etc. (Section 11.1), disinfection (Section 11.3), storage (Section 11.5) and equipment withdrawn from service (Section 11.6).

This general advice is based on British Standard **BS EN 1891: 1998 ‘Low stretch kernmantel ropes’** (Annex A, Informative), which contains advice on the care and maintenance of man-made fibres (the Annex was written with polyamide and polyester in mind, but some of the recommendations apply to low stretch kernmantel ropes made from any permitted material). It is based on **BS 7648: 1993 ‘Double braided ropes made from man-made fibres’** (Annex C, Informative), which gives recommendations for inspection and care of polyamide and polyester double braided ropes in use. BS 7648: 1993 is, in turn, based on **BS 4928: 1985 ‘Man-made fibre ropes’** [19] (Annex C). This deals with the inspection and care of polyamide (nylon), polyester, polyethylene and polypropylene filament ropes in use.

The Guidelines note (Section 11.1.2) that “... the most common cause of strength loss in textile equipment is through abrasion (either by grit working into the strands or by chafing against sharp or rough edges) or mechanical damage ...” . It suggests that soiled textile items may be “... washed in clean water (maximum temperature 40°C) with pure soap or a mild detergent ...” (pH 5.5 to 8.5) and “... then rinsed in cold, clean water ... wet equipment ... should always be allowed to dry naturally in a warm room away from direct heat ...”.

The Guidelines also state that “... textiles that have been in contact with rust should be washed ... Textiles with permanent rust marks should be treated with suspicion: recent tests [20] indicate that rust has a definite weakening effect on polyamides ...”.

Furthermore, “... after any necessary cleaning and drying, equipment should be stored unpacked in a cool, dry, dark place in a chemically neutral environment away from excessive heat or heat sources, high humidity, sharp edges, corrosives or other possible causes of damage. Equipment should not be stored wet ...”.

This advice (above) is generic in nature and reference must always be made to the appropriate manufacturer’s instructions. It is not always easy to distinguish between polyamide and polyester products, particularly when soiled.

The **Australian Standard, AS/NZS 1891.1: 1995** ‘Industrial fall-arrest systems and devices, Part 1: Safety belts and harnesses’ (Appendix B, ‘Determination of Resistance of Webbing to Light -

[18] http://www.osha-slc.gov/doc/outreachtraining/htmlfiles/subpartm.html

[19] *BS 2052: 1989 [Withdrawn] ‘Ropes made from manila, sisal, hemp, cotton and coir’ (Appendix D, ‘Guidance on the safe use and care of fibre ropes’) contains information prepared in order to assist purchasers who have adopted BS 4928 as a means of safeguarding the quality of the rope they buy.*

[20] *No source reference is given.*

Normative') - under revision - sets out the methods for determination of the resistance of webbing to light under both daylight and artificial conditions. Test specimens are exposed, together with a blue lightfastness standard[21] to outdoor or artificial light. Exposure time is determined by the fading of the blue standard to a nominated level. Specimens are then subjected to a breaking strength test and the result expressed as a percentage of the breaking strength determined for the batch of webbing.

For daylight exposure, equipment as specified in AS 2001.4.1 ('Method 4.1: Colourfastness tests - Definitions and general requirements') is required. For artificial light exposure, a single enclosed carbon arc fading machine complying with Method 5660 of US Federal Test Method Standard 191 is required. Specimens comprise six samples: three subject to exposure to light and the other three stored in darkness during the exposure period.

The **US Federal Test Method Standard No. 191A** (a copy of the July 1978 Edition was obtained [22]) gives the requirements for the carbon-arc lamp fading apparatus. It also indicates how to determine the fading rate, using standard light-sensitive paper, and specifies the length of exposure (from which it is possible to distinguish a 'pass' or 'fail', depending on the extent of fading).

A **Petzl CD-Rom** [23] includes visual guidance on the inspection of PPE. Sample inspection forms are available, including one for lanyards and another for harnesses. These give prompts on the items elements to be examined during a visual check of safety components.

Appendix B of the (now withdrawn) British Standard, **BS 8093: 1991**, Code of Practice for 'The use of safety nets, containment nets and sheets on constructional works', includes a summary of properties of various man-made fibre products (Refer to Annex K of this Report).

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[21] *Ref. AS 2001.4.2, 'Method of Tests for Textiles: Part 4, Colourfastness Tests'.*
[22] *Mr C Turner (WorkCover, NSW, Australia) faxed a copy of US Federal Test Method 5660, Standard No. 191A (1978 Edition).*
[23] *Petzl CD-Rom - Title: 'Checking of PPE', Version 1.1, 2000, Ref. Z29 - ENG.*

7 OTHER CONTACTS

At the **National Safety Council (NSC) Expo** (17th October 2000, Orlando, Florida) I discussed, briefly, the issue of lanyards and uv-degradation with Mr J Feldstein (MSA Rose, Head of USA Delegation to ISO/TC94/SC4). As a point of interest: he has undertaken some testing on a 10,000 lb. lanyard, which lost half its strength in a period of one month. He noted that US Standards do not cover uv-degradation and that it is left to the manufacturers to provide advice on their products.

Mr C Turner (Engineer, Construction Team, WorkCover, New South Wales) provided a copy of a **'Report to Coroner - 1998 Sydney to Hobart Yacht Race - Yachting Harnesses and Lines'**.

A copy of the Report was obtained after it was indicated (through contact with Mr P Ferguson, Australian Delegate to ISO/TC94/SC4, July 2000, London) that there had been an incident involving a lanyard and harness during the 1998 Sydney to Hobart Yacht Race.

The Report indicated that "... The manner of the failure of both lines was virtually identical in that the stitching failed completely at one end and partially at the other, with almost no damage to the webbing ..." (Section 2). An initial inspection had indicate that "... The used harnesses and lines appeared to have been in excellent condition, with no visible signs of physical damage or degradation ... (and) ... the lack of webbing damage in this case raises the possibility that the stitched joint was significantly weaker than the webbing, because of the joint design, thread selection or degradation of the stitching ...". Testing of 'replica' samples indicated that "... The stitching was the weak point in the lines ..." (Section 8a).

8 RELEVANT STANDARDS

The European and British Standards appropriate to energy absorbers and lanyards are **BS EN 354: 1993** 'Personal protective equipment against falls from a height - Lanyards' and **BS EN 355: 1993** 'Personal protective equipment against falls from a height - Energy absorbers', respectively.

BS EN 355 (Energy absorbers) requires that:

- "...if an energy absorber is incorporated in a lanyard (i.e. the energy absorber cannot be removed without mutilating the lanyard, or without the use of a special tool), the lanyard shall comply with 4.2 of EN 354: 1992 ..." (Clause 4.2, Materials and construction);

- "... when tested ... with a force of 15 kN the fully developed energy absorber shall withstand the static strength without tearing or rupture ..." (Clause 4.5, Static Strength); and

- "... the braking force ... shall not exceed 6.0 kN ..." (Clause 4.4, Dynamic Performance).

BS EN 354 (Lanyards) gives requirements for:

- Materials and Construction (Clause 4.2) - General (4.2.1), Fibre ropes and webbing (4.2.2), Wire ropes (4.2.3), Chains (4.2.4) and Connectors (4.2.5) However, the clause does not give any performance requirements for *strength*, which are actually contained within Clause 4.3;

- Static strength (Clause 4.3) - states "... a lanyard made entirely from textile material or textile lanyard elements, e.g. synthetic fibre ropes or webbing, including its textile terminations and if applicable its adjustment device shall sustain a force of at least 22 kN without tearing or rupture of any lanyard element when tested as described in 5.1 ...");

- Clause 5.1 requires that "... the static strength test (apparatus) shall comply with 4.1 [24] of EN 364: 1992 ..." and "... the static strength test shall be conducted as described in 5.2.2 [25] of EN 364: 1992 ..."; and

- Clause 4.3 (Dynamic strength) requires that "... lanyards with an incorporated adjustment device for the length shall withstand a drop test ...". There are not dynamic requirements where the lanyard can not be adjusted.

The **BS EN 364: 1992** (Clause 5.2.2) requires that:

- "... maintain the force for a period of 3 min and observe that the lanyard does not fracture ...".

It is apparent, therefore, that there is an anomaly between the 15 kN and 22 kN requirements.

BS EN 364: 1992 contains 'conditioning' requirements for fall arresters, but there are no degradation or ageing requirements for lanyards or energy absorbers, other than those in EN 363: 1992, 'Personal protective equipment against falls from a height - Fall arrest systems' that state "... a fall arrest system shall be so designed ... that in the foreseeable conditions of use for which it is intended the user can perform the risk-related activity whilst enjoying appropriate protection of the highest possible level ..." (Clause 5.1, Design and ergonomics).

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[24] *Static testing machines.*
[25] *Static strength test procedure.*

In **ISO 10333-2: 2000**, 'Personal fall-arrest systems - Part 2: Lanyards and energy absorbers' (First edition, 2000-03-15) there is a requirement that "... a fully deployed energy absorber shall withstand a force 22 kN [26] for Type 1 [27] or 15 kN for Type 2 [28] without tear or rupture ..." (Clause 4.3.6).

Lanyards (Clause 4.2.6) "... shall sustain a force as specified in Table 1 without tearing or rupture of any element ...". Table 1, Webbing-based lanyards, requires a static strength of 22 kN and notes that "... the higher strength requirement for textile materials [29] is necessary as these materials are more prone to wear and are more vulnerable to damage than their metallic counterparts ...".

After conditioning (which includes elevated temperature, wet, cold, wet and cold) there are dynamic performance requirements (Clause 4.3.7). These are given as optional but "... strongly recommended where it is known that the energy absorber is intended for use in extremes of climate ...".

It is interesting to note that the (now superseded) British Standard, **BS 1398: 1979 (as amended)** 'Specification for industrial safety belts, harnesses and safety lanyards' required the yarn for webbing lanyards to be "... virgin, bright, high-tenacity polyamide, or nylon, or polyester fibres having a uniform breaking strength ... and shall have a minimum breaking force of 20 kN (2040 kgf) and have a maximum width of 50 mm ..." (Clause 6.3).

At a Meeting of **CEN/TC160/VG11** 'Co-ordination of Notified Bodies' held at Seville, Spain (2nd/3rd November 2000) it was noted that "... EN 354 ... The general view is that this Standard causes much confusion and there have been requests by French Notified Bodies for its withdrawal. It was thought that the original intention was to provide a test procedure for lanyards sold as separate elements for attachment to energy absorbers by the end user ... There was also discussion on the possible reasons for the difference in static strength requirements between EN 355 (15 kN) and EN 354 (22 kN). These ranged from the fact that EN 355 includes an energy absorber to limit forces, to a technical error/inconsistency in the production of the Standards or even because the energy absorber is protected by a sealed wrapping and the lanyard is not, a higher force is required for a new lanyard as it may deteriorate more rapidly than the energy absorber due to exposure to the elements ..." (00/565146, Item 3).

The UK Delegate (Mr P Doughty, SATRA) "... tabled a document about the recent accident in Ireland which resulted in a fatality ... no other member of VG11 had experienced such a dramatic loss in strength and they agreed that this was most likely to be an isolated incident specific to this one manufacturer ..." (Item 4). Mr Doughty agreed to forward the results of the HSE investigation when available.

The issue of lanyards and energy absorbers was discussed at a Meeting of **CEN/TC160/WG2** on 22/23rd January 2001 and, in the Report by Mr P Seddon, the requirement for energy absorbers to withstand 15 kN in the static test (and not 22 kN as in EN 354) was "... discovered to be a long-time mistake ..." although "... some members believed that there were reasons for the lower requirement, but the Convenor confirmed that the intention had always been that lanyards incorporated with an energy absorber should withstand 22 kN ...". Discussion followed as to how the mistake could be remedied and an amendment via. the Unique Acceptance Procedure (UAP) was suggested (BSI Ref. 01/560563).

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[26] The ISO 10333-2 requirement of 22 kN is influenced by an US law, stating that fall arrest equipment has to be a minimum of 5000 lbs. (approx. 22 kN).

[27] Used in a personal fall arrest system (PFAS) where, due to installation, the potential free-fall distance can be limited to a maximum of 1.8 m and, if a fall takes place, the arresting force is limited to a maximum of 4.0 kN.

[28] Used in a personal fall arrest system (PFAS) where, due to installation, the potential free-fall distance can be limited to a maximum of 4 m and, if a fall takes place, the arresting force is limited to a maximum of 6.0 kN.

[29] Wire-based-rope lanyards have a force requirement of 15 kN.

9 ARTIFICIAL AGEING STANDARDS

There is an ISO Standard relating to methods of exposure to laboratory light sources: **ISO 4892, 'Plastics: Methods of exposure to laboratory light sources'**. It comes in several Parts:

- Part 1: General Guidance (ISO 4892-1, Second Edition, 1999-07-01);
- Part 2: Xenon arc sources (BS EN ISO 4892-2: 2000 (as amended));
- Part 3: Fluorescent UV lamps (BS EN ISO 4892-3: 2000 (as amended)); and
- Part 4: Open-flame carbon-arc lamps (ISO 4892-4, First Edition, 1994-05-01).

Part 1 gives a lot of general guidance. It is often necessary to determine more rapidly (than with outdoor exposures to daylight) "... the effects of light, heat and moisture on the physical, chemical and optical properties of plastics with accelerated laboratory exposure tests that use specific laboratory light sources ...". However, "... relating results from accelerated laboratory exposures to those obtained in actual-use conditions is difficult because of variability in both types of exposure and because laboratory tests often do not reproduce all the exposure stresses experienced by plastics exposed in actual-use conditions. No single laboratory exposure test can be specified as a total simulation of actual use exposures ..." (Introduction).

When conducting exposures in devices which use a laboratory light source "... it is important to consider how well the accelerated-test conditions simulate the actual-use environment for the plastic being tested ..." (Clause 4.1.1). The relative durability of materials in actual-use conditions can be very different in different locations because of differences in uv-radiation, time of wetness, relative humidity, temperature, pollutants and other factors ..." (Clause 4.1.2). It is stated that "... even though it is very tempting, calculation of an 'acceleration factor' relating 'x' hours, or megajoules, of radiant exposure in an accelerated laboratory test to 'y' months, or years, of actual exposure is not recommended. These acceleration factors or not valid for several reasons ... a) acceleration factors are material-dependent ... b) variability in the rate of degradation in both actual-use and accelerated laboratory exposure tests ... c) acceleration factors calculated based on the ratio of irradiance between a laboratory light source and daylight ... do not take into consideration the effects of temperature, moisture and differences in spectral power distribution between the laboratory light source and daylight ..." (Clause 4.1.3).

There is a note stating that "... if use of an acceleration factor is decided in spite of the warnings given in this Standard, such acceleration factors for a particular material are only valid if they are based on data from a sufficient number of separate exterior or indoor environmental tests and accelerated laboratory exposures so that results used to relate times to failure in each exposure can be analysed using statistical methods ..." (Clause 4.1.3).

There are a number of factors that may decrease the degree of correlation between accelerated tests using laboratory light sources and exterior exposures. These include: a) differences in the spectral distribution of the laboratory light source and daylight; b) light intensities higher than those experienced in actual-use conditions; c) exposure cycles that use continuous exposure to light from a laboratory light source without any dark periods; d) specimen temperatures higher than those in actual conditions ..." (Clause 4.1.4). Annex A of ISO 4892-1: 1999 gives more detailed information on these factors.

Results from accelerated exposure tests conducted in accordance with the Standard are best used to compare the relative performance of materials. Comparisons between materials are best made when the materials are tested at the same time in the same exposure device (Clause 4.2.1). It is "... strongly recommended that at least one control material be exposed with each test for the purpose of comparing performance of the test materials to that of the control (Clause 4.2.1.1). **CIE Publication No. 85: 1989** [30] provides data on solar spectral irradiance for typical atmospheric conditions, which can be used as a basis for comparing laboratory light sources with daylight ..." (Clause 5.1.6).

The methods used for the preparation of test specimens can have a significant impact on their apparent durability. It should preferably be closely related to the method normally used to process the material in typical applications (Clause 6.1.1). The dimensions of the test specimens are normally those specified in the appropriate test method for the property or properties to be measured after exposure (Clause 6.1). Specimens shall be appropriately conditioned before all property measurements. The properties of some plastics are very sensitive to moisture content (Clause 6.3.2).

The **EN 1898**, 'Specification for flexible intermediate bulk containers for non-dangerous goods' contains Annex A (normative) on a uv resistance test for FIBCs (Flexible Intermediate Bulk Containers).

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[30] *Commission Internationale de L'Eclairage (International Commission on Illumination), http://www.cie.co.at*

10 EC DIRECTIVE

The **PPE (EC Directive) Regulations 1992** - which implement the EC Directive 89/686/EEC - give the basic health and safety requirements (Annex II) applicable to PPE. With respect to falls from height (Annex II, Item 3.1.2.2) they state that "... PPE designed to prevent falls from a height or their effects must incorporate a body harness and an attachment system which can be connected to a reliable anchorage point. It must be designed so that under the foreseeable conditions of use the vertical drop of the user is minimised to prevent collision with obstacles and the braking force does not, however, attain the threshold value at which physical injury or the tearing or rupture of any PPE component which might cause the user to fall can be expected to occur ... It must also ensure that after braking the user is maintained in a correct position in which he may await help if necessary ...".

The PPE (EC Directive) Regulations 1992 also require (Annex II, 1.4) information to be supplied by the manufacturer concerning "... storage, use, cleaning, maintenance, servicing and disinfection ..." and "... the obsolescence deadline or period of obsolescence of PPE or certain of its components ...".

Also, the Regulations (Annex II, 2.4 - PPE subject to ageing) state "... If it is known that the design performances of new PPE may be significantly affected by ageing, the date of manufacture and/or, if possible, the date of obsolescence, must be indelibly inscribed on every PPE item ...". Furthermore, "... If a manufacturer is unable to give an undertaking with regard to the useful life of PPE, his notes must provided all the information to enable the purchaser or user to establish a reasonable obsolescence date, bearing in mind the quality level of the model and the effective conditions of storage, use, cleaning, servicing and maintenance ...".

11 LEGISLATION

The **Personal Protective Equipment at Work Regulations 1992** (part of the 'six pack') require that:

- "... every employer shall provide suitable personal protective equipment ..." (Reg. 4(1));
- "... it is appropriate for the risk or risks involved and the conditions at the place where exposure to the risk may occur ..." (Reg. 4(3));
- "...any personal protective equipment ... is maintained (including replaced or cleaned as appropriate) ..." (Reg. 7(1));
- "... that appropriate accommodation is provided for that personal protective equipment ..." (Reg. 8);
- "... that the employee is provided with such information, instruction and training as is adequate ..." (Reg. 9(1));
- "... Every employer shall take all reasonable steps to ensure that any personal protective equipment provided to his employees ... is properly used ..." (Reg. 10(1)); and
- "... Every employee shall use any personal protective equipment provided to him ... in accordance both with any training ... and the instructions ... provided to him ..." (Reg. 10(2)).

12 PERSONAL SAFETY MANUFACTURERS' ASSOCIATION(PSMA)

At a meeting, held at HSE Bootle on 7th July 2000, Mr A Jones (Pammenter and Petrie) suggested that the 'Height and Access Committee' of the Personal Safety Manufacturers' Association (PSMA) may be an appropriate forum where the issue of lanyard degradation issue, and perhaps others, could be discussed. The Committee has just (June 2001) proposed the following 'Aims' and 'Objectives':

Aims - The aims of the Group are "... a) the provision of a forum for the free and informal exchange of experience and opinion; b) to promote the interests of Members and the users of their products; and c) to define and promote best practice; d) to share information regarding incidents."

Objectives - The objectives of the Group include promotion of "... the design, manufacture and testing of high quality equipment and systems for PPE and other equipment relevant to: prevention of falls, fall arrest, work positioning, evacuation/escape and confined space access ... the awareness of the need for personal protective equipment and other equipment ... the correct selection and use of PPE and associated equipment in accordance with current legislation guidance and standards ... education and training in respect of selection, use, installation, inspection, care and maintenance of PPE and other equipment ... promote training, assessment and audit to manufacturers, assemblers, installers and suppliers of equipment".

13 DISCUSSION AND RECOMMENDATIONS

From the information presented in Sections 5 and 6 it can be seen that (even without considering the detailed chemistry of polymers) the degradation and ageing of webbing products is a complex issue. Degradation has a number of possible causes including abuse, general wear and tear, edge damage, uv, dirt and grit, chemicals, etc..

For the purposes of discussing the issues arising from this investigation, and making recommendations, the following broad headings will be used:

- Testing Programme;
- Standards; and
- Information for the User.

Testing Programme

A high proportion (60%) of the lanyards tested did not achieve the static test performance requirements of EN 355. The Standard is primarily designed for the 'type testing' of new products and does not contain performance requirements for the residual strength of used, or 'in-service', energy absorbing lanyards. The testing, however, has indicated a reduction in the tensile strength of webbing of at least 50% (typically) over a period of four to five years, resulting from all sources of degradation (including abuse).

There was a greater rate of failures amongst the energy absorbing lanyards manufactured from webbing, by comparison to rope (although the sample size for the latter was much smaller).

The research highlighted the importance of detailed inspection by a competent person, with some correlation between the visual condition of the lanyard and the performance in the static tensile tests. Indeed, a number of the lanyards acquired should not, in my opinion, have been in use.

Importantly, a number of lanyards assessed visually as having only 'none/general' or 'slight' damage also failed the static strength requirement (with failure loads varying between 11.39 kN and 15 kN), although this still gives a factor of safety of approximately two (based on the maximum impact requirement of 6 kN).

The test programme highlighted a number of failures at the interface loop between the absorber and lanyard, or at a distance of about 25 mm from the absorber/lanyard stitching (possibly due to damage from the protective sleeve). Also, there was a tendency for identification labels to be missing.

> ***<u>Recommendation 1</u> - Manufacturers should review the longer-term integrity of their product marking, e.g. labels; whether improvements can be made at loops (to reduce abrasion) and whether the "shrink wrapping" of energy absorbers may damage the textile and affect strength.***

A major factor on the strength of these products is, in my opinion, the degree of surface and internal abrasion. This is a problem which is progressive in nature, perhaps with the user not being overly aware of its presence. The microscopic examination also detected a number of particulate contaminants.

Ultraviolet radiation is also, in my opinion, an important factor in potential degradation although, as with most other factors affecting man-made fibre products, it is difficult to quantify. However, it has been shown that known exposure is difficult to detect visually. What is clear, in my opinion, is that a knowledge of the light resistance, etc. of basic yarns is not sufficient to predict the behaviour of a woven product. Whilst there is much information available about basic yarns, not as much is evident for the finished product (important when most manufacturers' products differ).

These issues, in conjunction with the tensile test results, all highlight the importance of proper maintenance and equipment storage. In my opinion, equipment requires pre-use checks; detailed inspections and (as appropriate) interim inspection, in order to identify defects or damage. In particular, if there is no record of a detailed inspection the equipment should, in my opinion, be withdrawn from use immediately and referred to a competent person for a detailed inspection (Refer to draft Operational Circular - Annex E [31] - for further advice).

Recommendation 2 ***- Textile equipment requires proper inspection, maintenance (which may include cleaning) and storage. Equipment should be subject to pre-use checks, detailed inspection and (as appropriate) interim inspection by competent persons.***

In my opinion, there should be a detailed inspection at least every six months, although BS EN 365 indicates "... at least every twelve months ...". For frequently used equipment it is suggested that this be increased to at least every three months, particularly when used in arduous environments. The competent person should decide, having consulted the manufacturer's advice, whether laundering is required (or appropriate).

Recommendation 3 ***- Frequently used equipment, particularly that used in arduous environments, should be subject to a detailed inspection at least every three months (otherwise, it should be at least every six months). HSE should make available advice to this effect. These intervals are more frequent than generally appears to be current practice.***

There is anecdotal evidence that equipment is not being correctly stored, maintained and inspected. Employers should establish a regime for the inspection of personal protective equipment for protection against falls from a height, e.g. training of users and competent persons, frequency of inspection, etc.. In addition, suitable storage conditions are important, e.g. cool, dry and dark (and away from excessive heat or other possible sources of damage).

[31] The text attached (Annex E) is the final draft of OC 282/29.

Standards

The minimum static strength for all items of PPE in a fall arrest system is (currently) given as 15 kN and the maximum impact force must not be greater than 6 kN. Therefore, typically, use of an energy absorber (or other form of energy dissipation) will give a factor of safety of 2.5. Presently, the 15 kN static strength [32] applies to most components (including the harness) made from textiles, with the exception of lanyards (to BS EN 354). Lanyards are more subject to abuse and/or wear and tear than most other items of PPE, e.g. they can be used as anchor slings around points on the structure, and wear quicker than metal components. Accordingly, the minimum strength of a lanyard was set (by CEN) to 22 kN to compensate for this (although when the lanyard is combined with an energy absorber a static strength of 15 kN was deemed to be sufficient).

However, early discussions with CEN/TC160/WG2 have indicated that the 15 kN static test requirement in BS EN 355 should actually be 22 kN. The BSI Technical Committee (PH/5) should seek, as a matter of urgency, to raise this issue with CEN/TC160 and, if confirmed, request an amendment [33].

***Recommendation 4* - BSI Technical Committee PH/5 should request that CEN Technical Committee TC160, as a matter of urgency, confirm that the static test requirement in BS EN 355: 1993 (15 kN) is incorrect (and should be 22 kN). If it is, as seems likely, PH/5 should seek an immediate amendment.**

CEN/TC160/WG2 have already produced amendments to ENs 354 and 355, yet to be published, and will shortly be considering future revisions (perhaps, it has been suggested, using the ISO Standard, ISO 10333: Part 1).

With this revision in mind, it is recommended that there be minimum performance requirements for the degradation of man-made fibre materials.

***Recommendation 5* - Any future revision of BS ENs 354 and 355 should include minimum performance requirements for the degradation of man-made textile materials.**

Prior to being made aware of the apparent error in the Standard it was my opinion that a user, for example in 3 years time or more (say), should reasonably be able to expect that any energy absorbing lanyard they are using (which, if all is not well, will arrest their fall and save a life) should still meet the requirements of the Standard.

However, bearing in mind the possible anomaly in the Standard, it does not seem unreasonable for a user to expect a factor of safety of at least two, although the setting of any performance requirements must go hand-in-hand with the need for inspection procedures, training, storage and maintenance, etc.. This would, in my opinion, accord with the notion in the PPE (EC Directive) Regulations 1992 (Annex II, Basic Health and Safety Requirements) that "... ppe must be designed and manufactured that in the foreseeable conditions of use for which it is intended the user can perform the risk-related activity normally whilst enjoying appropriate protection of the highest possible level ..." (Clause 1.1.1).

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[32] *In addition to a static test there is also an onerous dynamic test (FF2, 100 kg mass; and a 100 kg mass is the equivalent of a person of approximately 130 kg). Typical impact forces on harness/lanyard personal fall arrest systems are presented in Annex F.*

[33] *It would also be worth clarifying whether, during static testing, the peak (or average) force in an energy absorber should exceed 6 kN.*

Whilst it is recognised that the various different mechanisms contributing to degradation are not (currently) easy to quantify precisely, or isolate, it is recommended that consideration be given, in particular, to requirements for uv-degradation and abrasion. In this respect there will be information in Australia that can be evaluated, as there is a requirement in their Standard to take account of uv-degradation. In addition, there are abrasion requirements in the seat belt industry.

***Recommendation 6* - CEN/TC160 should ascertain the extent of, and evaluate, any available information relating to uv-degradation and abrasion of man-made textile materials [34]. Consideration should also be given to the possible future effects of ozone depletion on textile materials [35].**

Although there is much information available about the degradation of fibres, this work has indicated that there is a need, on the whole, for industry to undertake more research into the degradation of webbing as a woven and sewn product.

***Recommendation 7* - Manufacturers should (if they do not currently have appropriate information) undertake further research into the various causes of webbing and rope degradation, particularly of woven and sewn products.**

The HSE are planning, in the short-term, to undertake further Research (see Section 15) to explore some of the issues that contribute to the degradation of man-made fibre webbing. In particular, it is hoped to examine artificial ageing which, in itself, is a issue where there are many variables. Also, as solar radiation will vary across Europe it would seem prudent, with ever widening markets, to ascertain the extent of this variation. In the longer-term it is hoped to undertake work to ascertain the effect of acids, e.g. hardening, weakening, etc..

***Recommendation 8* - HSE, in both the short- and medium-term, should undertake research to explore some of the issues that contribute to the degradation of webbing.**

Information for the User

The prompt availability of relevant manufacturers' literature was limited; although most, but not all, were eventually able to provide more detailed information. Much of this, however, tends to relate to the performance of the yarns, rather than that of the webbing as a woven product. In my opinion, the degree and depth of technical support relating to this issue could, as a whole, be improved.

***Recommendation 9* - Manufacturers should review the prompt availability of technical support relating to the performance of their yarns, rope and webbing.**

[34] *Products within Europe are now sold and distributed across a geographically expansive range of Member States.*

[35] *http://www.doc.mmu.ac.uk/aric/eae/Ozone_Depletion/Older/Materials_Damage.html*

The issue of 'obsolescence' is one where better clarity and availability of information and instructions would assist employers and users in understanding the issues involved. When asked to consider, under the PPE (EC Directive) Regulations 1992, what you consider as 'obsolescence' few specific responses were received.

> ***Recommendation 10*** ***- Manufacturers should review the availability and clarity of instructions on the 'obsolescence' and 'lifetime' of their products.***

The 'obsolescence' of a product can be hard to define and, as stated above, there appears to be limited information on whether woven textiles (inc. those treated with inhibitors against uv degradation typically used in lanyards and energy absorbers) will be significantly affected by natural ageing. However, there appears to be a broad 'rule of thumb' [36] that a user should be able to expect an energy absorbing lanyard to last for five years if (as is unlikely) it is kept in perfect condition.

The 'lifetime' of a product, therefore, depends upon the precise use (excluding a fall) to which the energy absorbing lanyard is being put. If it is abused, or used in poor conditions, its life could be no more than one use. Detailed inspection by a competent person should determine reasonably the condition of the component.

Despite this, detailed inspection even by a competent person might not reveal everything, e.g. hidden damage such as chemical contamination, or damage to internal fibres, through lack of care by the user. Any inspection process is, to some degree, subjective and only a test to give an accurate assessment of a component's tensile strength, which by then is too late. However, items of textile PPE must not be proof loaded.

Some manufacturers, on occasions, receive 'out-of-service' equipment and it is recommended that, where this is their own label, they undertake testing, etc. to build up a profile of used equipment. This does not, at present, seem to be undertaken to any great extent.

> ***Recommendation 11*** ***- Manufacturers should, by testing, build up a profile of their own 'out-of-service' product(s).***

The future revision of EN 365 should help end users, by requiring more information to be provided by manufacturers, suppliers, etc.. Manufacturers could, in my opinion, improve the nature of advice available on this issue, e.g. product literature, information sheets, etc..

> ***Recommendation 12*** ***- Manufacturers should, when available for public comment, seek to review the forthcoming revision of BS EN 365: 1993, "PPE against falls from a height - General requirements for instructions for use and for marking".***

Industry should explore ways of promoting awareness of 'work at height' (or 'fall protection') issues, e.g. by manufacturers discussing issues of concern or common interest (within PSMA, for example) and by providing, or promoting, 'best practice'. There is scope for the provision of a framework

[36] *For example, some advice states that "... as a practical rule: The life of a rope or harness may be taken to start at the time of purchase (assuming proper storage by retailers). The storage life of the item away from heat, light, etc. is, on the side of caution, five years. The subsequent active life of the item may be as low as a single use, or could stretch for another five years." (Lyon Equipment Ltd.'s 'Obsolescence of Textile Based Ropes, Harnesses and Slings for Mountaineering and Work Positioning', General Advice Without Prejudice (Rev. 1), June 1993).*

syllabus (or ‘template’) for those who provide work at height training - thus providing a ‘benchmark’ for training. Industry as a whole should ensure, in my opinion, that there is a better level of tuition available to site workers, particularly in the pre-use check of lanyards, harnesses, etc. (the Construction Industry Training Board (CITB) have shown some interest in this area).

<u>Recommendation 13</u> - Industry (with HSE) should explore ways of promoting an increased awareness of ‘work at height’ issues (‘fall protection’); particularly the training for inspection by competent persons.

PH/5 has a new work item to produce a British Standard Code of Practice for ‘The selection, use and maintenance of fall protection systems and equipment’ (estimated completion date, end of 2002). I understand that the Construction Industry Research and Information Association (CIRIA) may also be considering producing practical guidance.

14 CONCLUSIONS

The course of the investigation has:

- made a number of recommendations (see 'Executive Summary');
- highlighted an apparent anomaly in BS EN 355;
- reviewed the reasons for the degradation of energy absorbing lanyards;
- made recommendations for an amendment to the Standard (and identified areas for its future revision);
- given areas for future research; and
- recommended that there be an increased awareness of 'work at height' issues (particularly the inspection, storage and cleaning of textile equipment).

15 FURTHER RESEARCH

In order to explore some of the issues that contribute to degradation of man-made fibre webbing it is proposed to undertake some research to examine, separately, the effects of:

- uv-degradation (through exposure to an artificial light source);
- surface damage (by cyclic testing, perhaps akin to that used for car seat belts);
- edge damage (such as 'cuts and nicks');
- natural ageing (by exposure to natural sunlight and weather); and
- dirt and grit (looking at fibre abrasion).

It is also hoped to obtain both nylon and polyester webbing, in different widths, thicknesses and colour.

Consideration will also be given to:

- further static tests with energy absorbing lanyards from other manufacturers; and
- dynamic testing to examine potential 'interface' failures, e.g. lanyard/absorber or lanyard/screwlink.

Longer term, future research may also include the effects of moisture, temperature, the rate of loading during static testing, and chemicals.

16 REFERENCES

References are given, where possible, throughout the text of this Report. During the course of the investigation a number of other sources of information were also obtained. These are listed in the 'Bibliography' (below).

17 BIBLIOGRAPHY

The **ASTM Book of Standards, Volume 14** - General Methods and Instrumentation, Volume 14.04 - Laboratory Apparatus; Degradation of Material, Filtration; SI; Oxygen Fire Safety (also available from ANSI):

- E41-92 (Reapproved 1998), 'Standard Terminology Relating To Conditioning';
- G7-97, 'Standard Practice for Atmospheric Exposure Testing of Nonmetallic Materials';
- G23-96, 'Standard Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials';
- G24-97, 'Standard Practice for Conducting Exposures to Daylight Filtered Through Glass'; and
- G26-96, 'Standard Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials'.

The Standard **BS EN ISO 105-B02: 1999** (inc. Corrigendum No. 1), 'Textiles - Tests for colour fastness - Part B02: Colour fastness to artificial light: Xenon arc fading lamp test'.

DuPont Engineering Fibres, **'Kevlar - Visible Performance. Invisible Strength'** (06/97); and **Kevlar Aramid Fibre 'Technical Guide'** (4/00).

prEN 1492-1 (Final Draft, March 2000) **'Textile slings - Safety - Part 1: Specification for flat woven webbing slings, made of man-made fibres, for general purpose use'**. Appendix D gives informative advice on the suggested content of information to be provided by the manufacturer with flat woven webbing slings.

BS 3481: Part 2: 1983 **'Flat lifting slings - Part 2. Specification for flat woven webbing slings made of man-made fibre for general service'** (as amended) gives practical advice (Appendix B) for the use and maintenance of flat woven slings.

BS EN 1891: 1998, **'Personal protective equipment for the prevention of falls from a height - Low stretch kernmantel ropes'** gives recommendations (Annex A, Informative) for the inspection and care of low stretch kernmantel ropes in use.

BS 4928: 1985, **'Specification for Man-made fibre ropes'** gives advice (Appendix C) on the inspection and care of polyamide (nylon), polyester, polyethylene and polypropylene filament ropes in use, including chemical causes of damage.

BS 7648: 1993, **'Specification for Double braided ropes made from man-made fibre'** gives recommendations (Annex C, Informative) for the inspection and care of polyamide and polyester double braided ropes in use.

BS 2052: 1989, **'Specification for Ropes made from manila, sisal, hemp, cotton and coir'** gives guidance (Appendix D) on the safe use and care of fibre ropes.

The **'Made-up Textile Association'** [37] was founded in 1919 and is the UK's only trade body representing the industrial textiles industry. Some limited information is given on their website, although they help to set quality Standards, Codes of Practice, etc..

The **'Plastics Design Library Handbook, 1994'** [38] includes a chapter on 'The Effect of UV Light and Weather on Plastics and Elastomers', which is a database publication providing data on the effect of ultra violet radiation (indoor and outdoor) and weather (i.e. outdoor weathering, accelerated weathering, accelerated outdoor weathering, ozone attack, thermal air ageing, thermal water ageing, microbiological attack, etc.) on the properties and appearance of plastics. Information is presented in easy to use graphical and tabular formats.

Association of British Mountaineering Equipment Manufacturers (ABMEM) **'PPE and CE Marking Explained'** which briefly explains the requirements of CE Marking.

During the investigation, copies of several sources of **information on resistance to chemicals** have been made available:

- Troll Safety Equipment Limited, 4pp (supplied by both Mr D Allport and Mr P Seddon);
- Ropes made from man-made fibres (Bridon Ropes and Fibres publication, Fifth section (E)) (supplied by Mr D Riches);
- Lyon Equipment: Enkalon (PA 6) and Enka Nylon (PA 66): Chemical resistance of Enka Fibres (supplied by Mr P Ramsden); and
- SpanSet Technical Information (supplied by Mr E Perry).

The **'Mechanical Engineer's Reference Book'** Materials, Properties and Selection [39], Page 7/106 et seq. describes the molecular make up, etc. of polymers.

Wuppertal 1998 (ISFP), **Personal Fall Arrest Systems (PFASs) Servicing, Maintenance and Inspection From the Manufacturer's Perspective**, by C Firl and T Wolner, DB Industries, USA.

Research: **UV-protection and Performance by Ciba**, http://www.cibasc.com/image.asp?id=343

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[37] *http://www.muta.org.uk*

[38] *http://search.rapra.net/publications/en/pdl08.asp*

[39] *Mechanical Engineer's Reference Book, 12th Edition, Edward H. Smith, Institution of Mechanical Engineers, ISBN 0-7506-1195-2.*

18 DEFINITIONS

The following definitions may be helpful when reading the text of this Report, or given References:

- Denier - Property unique to the fibres industry to describe the fineness (and, conversely, the cross-sectional area) of a filament, yarn, rope, etc.. It is defined as the weight in grams of 9,000 metres of the material. An alternative unit is 'dtex' (decitex): 1 dtex = 0.9 denier, i.e. the weight in grams of 10,000 metres of material.

- Filament - Smallest component of a yarn.

- Modulus - The property describing a material's resistance to extension. Its units are the same as those for 'tenacity'; most commonly, pounds per square inch (psi), grams per denier (gpd), Newtons per tex (N/tex), or pascals (Pa).

- Tenacity (Tensile Strength) - The ultimate strength exhibited by a material at the moment of failure based on a unit of the original (i.e. no load) cross section.

- Tex - The basic property, unique to the fibres industry, to describe the fineness of a filament, yarn, rope, etc. It is defined as the weight in grams of 1,000 meters of the material. Its US equivalent is 'denier': 1 tex = 9 denier. In many instances, 'decitex' (dtex) is used to keep fineness numbers about the same as the 'denier' values.

- Twist - The number of turns about its axis per unit length of yarn, e.g. 'turns per inch' (tpi) or 'turns per metre (t/m); 1 tpi = 39.37 t/m.

- Yarn - Bundle (assembly) of individual filaments.

- Langleys - 1,000 Langleys = 1 kg.cal./cm^2 = 1,000 gm.cal./cm^2 = 3,690 Btu/ft^2.

- 1 kJ = 0.948 Btu; 1 Btu = 1.055 kJ.

- 1 J/m^2s = 0.317 Btu/ft^2h; 1 Btu/ft^2h = 3.15J/m^2s.

ANNEXES

Annex A - Sequence of Events

Annex B - Meeting with Lanyard Manufacturers, etc., held at HSE, Bootle on 7 July 2000

Annex C - Resume of NEL Test Results

Annex D - Resume of HSL Findings

Annex E - Draft Operational Circular (OC)

Annex F - HSL Drop Tests

Annex G - Tensile Tests on Some Webbing Samples

Appendix H - Resume of Information Provided by Manufacturers, etc.

Annex I - Fall Arrest and LOLER

Annex J - Further Details of the DuPont Bulletins

Annex K - Summary of Properties of various Materials

Annex L - And Finally ...

ANNEX A - SEQUENCE OF EVENTS

On 13th March 2000 I received a telephone call from Mr R Breen, HM Principal Specialist Inspector, Scotland Regional Specialist Group (RSG), to say that he had been passed some papers by a Mr W Reilly, Health and Safety Authority (HSA), following a fatality in Eire. Mr Breen indicated that NEL Ltd., Glasgow (NEL), had undertaken tests on the energy absorbing lanyard that had failed, and also another of similar age. These had shown "... that there has been a marked decrease in the strength of the lanyard over its 3 or 4 year life ...".

Mr Breen had met, at NEL, with Mr F de Barra (HSA), Mr H Crawford (Consultant, ex NEL) and representatives of Murphy Structural Engineering (Contractor), seen the lanyards and discussed the test results. The nylon webbing was "... in a very poor condition and had it ever been examined by a competent person or the makers it would, in my opinion, (have) been withdrawn from service ...". It appeared that, in the past, the lanyard may have been choke-hitched around steelwork.

Mr Breen indicated that HSA's primary concern was that "... sections of the exposed webbing material (i.e. from the lanyard proper) failed at very low loads compared to webbing material taken from the protected area within the energy absorber ..." (one test result was as low as 2.133 kN, i.e. just 14.2% of the 15 kN type-test requirement).

NEL Ltd. had concluded that the exposed part of the lanyard had suffered degradation from an external source and, in the absence of any other obvious external source, concluded that this had been as the result of ultra violet light. However, they had not been able to present any evidence of ultra violet degradation. Chemical analysis had indicated the presence of silica, cement dust and weld spatter amongst other contaminants.

Mr Breen subsequently sent me a draft copy of a Report, prepared by NEL, entitled "Tests carried out on an energy absorbing lanyard involved in a fatal accident" (Ref. PPE002000, Feb. 2000) [40].

By coincidence I already had a pre-arranged visit to meet Mr D Hare (Engineer, Product Engineering Services) at NEL Ltd.. On 28th March 2000 I travelled to NEL's Laboratories at East Kilbride, Glasgow. Towards the end of my visit I was handed a further draft of the NEL Report and took the opportunity to review the photographs and load/displacement plots. I discussed the possibility of NEL Ltd. undertaking some further testing, on behalf of HSE.

On 30th March 2000 I spoke to Mr M Holden (HM Principal Specialist Inspector, Manchester RSG) who noted that he had concerns concerning the possible degradation of a work positioning strap, made from man-made fibre webbing, which had been recovered after a fatality during work on a pylon, and which appeared to have failed as a result of an overload whilst in a weakened condition arising from excessive wear.

On 30th March 2000 I spoke to Mr M Shearon (HM Inspector of Health and Safety, Construction Sector, London) who said he would ascertain whether the Field Operations Directorate (FOD) Inspectors could obtain, for testing, some 'life expired' energy absorbing lanyards. I also spoke to Mr C Wilson (Head of Field Engineering Section, HSL) in connection with the possibility of HSL undertaking investigative work and arranging for tensile testing to be undertaken by NEL Ltd..

On 12th April 2000 I spoke to Mr A Sneddon (Safety Manger, BNFL Sellafield) who had been asked by Mr Shearon if he could supply a number of energy absorbing lanyards for testing. I was subsequently informed that BNFL had acquired 40 No. lanyards from various of their site Contractors.

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[40] *The Final Report is Ref. 065/2000, Dated February 2000 (42pp).*

The issue was raised, without reference to specific products or manufacturers, at the meeting of the British Standards Institution (BSI) Technical Committee, PH/5 "Industrial Safety Belts and Harnesses" on 13th April 2000 (Ref. 00/561554, Letter Mr H Crawford to Mr DJ Fisher (Secretary)).

The Minutes (Ref. 00/561841) note that "... it was initially suggested that the static strength test for energy absorbers given in BS EN 355 should be changed to give an increased requirement (22 kN instead of 15 kN). Other members urged that more (research) should be done before making this a UK or Irish proposal ...". Members expressed their concern and the need for some urgent work was expressed.

Consequently, during the meeting, I undertook to initiate some joint research between the Health and Safety Laboratories (HSL) and NEL Ltd. to try and determine whether or not changes to Standards needed to be proposed.

I contacted Mr M Shearon (14th April 2000) to inform him of the outcome of the PH/5 Meeting and summarised my proposed recommendations for proceeding with the investigation.

In an Email, Mr Shearon (4th May 2000) indicated that, as the issue was wider than Construction, feedback and progress should be co-ordinated through the FOD Safety Unit (Mr D Willis, HM Inspector of Health and Safety).

On 4th May 2000, in an Email Mr C Wilson (HSL), I requested an estimate for lanyard examinations, etc. and his response to a draft Proposal from NEL Ltd. (Rcd. 28th April 2000). Mr Wilson responded on 16th May 2000 and, subsequently, Dr. W Geary (Section Head of Metallurgy and Materials, HSL) provided an updated cost estimate (19th May 2000).

The Final NEL Proposal was received on 25th April 2000 (Ref. PES/236, Dated April 2000). A GP30 (HSL Acknowledgement of Reactive Support Job) was then prepared by Dr. W Geary (13th June 2000) and submitted to TD2, allowing work the support work to commence (GP30, Revised 12th July 2000).

Not knowing the extent of the problem I decided to arrange a Meeting with technical representatives from eight of the main fall arrest equipment manufacturers, suppliers and distributors in the UK (Email 29th June 2000). A list of those attending the Meeting at HSE, Bootle (7th July 2000), and an 'Action List', is reproduced in this Report as Annex B.

At the Meeting, I outlined the circumstances surrounding the lanyard failure and raised issues relating to obsolescence, degradation, contaminants, Standards, provision of information, training, etc.. A list of questions, subsequently sent out by post (18th July 2000), was tabled with a request for an urgent response.

Responses to this request were received (from most, after a number of reminders) as follows: Troll Safety Equipment (No Date); Lyon Equipment Ltd. (28th August 2000); SpanSet (10th October 2000); Sala Group Ltd. (7th July 2000); Pammenter and Petrie (6th October 2000); Protecta International (17th November 2000); RidgeGear (2nd November 2000); and Tractel Training Solutions (24th October 2000).

At this Meeting, Mr A Jones (Regional Sales Manager, Pammenter and Petrie) suggested that an appropriate forum where this issue, and perhaps others, could be discussed further may be the 'Height and Access Committee' of the Personal Safety Manufacturers' Association (PSMA) (the latter is affiliated to the British Safety Industry Federation (BSIF)).

On 28th June 2000 I was visited by Mr G Gilbert (Safety Consultant, National Grid), a Member of PH/5, who expressed concern about the results of some recent testing that he had undertaken on a number of lanyards. He undertook to post me the test results (Received 3rd July 2000).

In order to be able to discuss the various issues on a 'one-to-one' basis I held Meetings with: Troll Safety Equipment (25th August 2000); Sala Group Ltd. (5th September 2000); Pammenter and Petrie (5th July 2000); Protecta International (26th July 2000); and RidgeGear (24th July 2000).

Following an Email (6th July 2000) I spoke to Mr F de Barra (HSA), on 14th July 2000, in connection with the lanyard incident. He indicated that he had met representatives of the manufacturer of the lanyard involved in the fatality, receiving some product information. He also indicated that HSA were considering issues such as service life, literature, training, etc..

As a result of the Meeting, and various other discussions, I prepared some interim advice and sent this to Mr N Ratty, FOD Safety Unit (25th July 2000).

On 27th July 2000 I contacted a number of the longer standing members of BSI Technical Committee PH/5, to seek clarification on the intended wording of the existing Standards, BS EN 354 and BS EN 355. Responses were received from: Messrs. Feathers (Letter, Rcd. 23rd August 2000); Crawford (Letters, 3rd August 2000 and 18th September 2000) and Seddon (Email, 7th August 2000).

At a Meeting of PH/5 (12th September 2000) I reported that the HSE testing programme in conjunction with NEL had started, with products from eight different suppliers. The Minutes (00/564399, 12th September 2000) note "... there was general support from PH/5 for the work being carried out ..." (Item 2).

Mr C Turner (Engineer, Construction Team, WorkCover, New South Wales) sent a copy of a 'Report to Coroner - 1998 Sydney to Hobart Yacht Race - Yachting Harnesses and Lines' which looked at the failure of a line (See Section 7, Email Rcd. 13th September 2000).

An article in 'Construction News' - headed 'Harnesses hit by safety scare' - appeared on 21st September 2000. This contained a number of inaccuracies and referred to "... an HSE spokeswomen ...". Mr M Shearon circulated a briefing note about the article to Mr K Myers (HM Chief Inspector of Construction), Dr. R Evans (Head of Sector), Mr B Brunswick and Mr A East (Unit 4, Construction Sector) on 29th September 2000.

Mr C Turner (WorkCover) faxed a copy of US Federal Test Method 5660, Standard No. 191A (1978 Edition) on 27th September 2000.

A Meeting of CEN/TC160/VG11 was held on 2nd/3rd November 2000, at which various issues relating to lanyards were raised.

I received the NEL Test Report (Report No, 230/2000, November 2000, Project No. HSE050), via Dr. W Geary (HSL), on 6th December 2000.

I met with Mr N Ratty and Mrs G Spurrier (FOD Safety Unit, Manchester) on 19th January 2001 to discuss a resume of the NEL Test Results. Although the HSL Contamination, etc. Testing Report had not been received it was agreed to circulate a draft OM (later OC), for comment, as a matter of urgency (originally drafted as a TD Minute).

I received an Email (24th January 2001) from Mr M O'Dea (Construction Inspector, HSA) - Mr F de Barra had left the HSA - and subsequently updated him (25th January 2001) on HSE's work. He noted "... the need for PPE traceability (every part to be uniquely labelled), daily user checks, annual servicing, finite life, and especially storage controls ...". He noted that they (the HSA) were "... also making users aware of the decrease in strength over time, even when not in use, i.e. uv light effects ...".

In a telecon with Mr S Linnitt, Tractel (25th January 2001), it was suggested that the Construction Industry Training Board (CITB) may be a forum through which awareness of work at height issues could be promoted.

I held a Meeting (25th January 2001) with Mr C Chapman (Latchway, and Chairman of PH/5) and appraised him of the preliminary findings of the NEL Research - prior to discussions at the PH/5 Meeting to be held on 31st January 2001.

On 26th January 2001 I received a telephone call from Mr P Seddon (PH/5) who had just returned from a Meeting of CEN/TC160/WG2. On my behalf (under 'AOB'), he raised some general issues about lanyard safety (some of the WG knew about HSE's work on lanyards, etc. and that a Report was being written). It was stated, by a German delegate who was involved in the original Standard (1993), that the static strength requirement for energy absorbers, as drafted, in BS EN 355 (i.e. 15 kN for 3 mins) was "... a mistake ..." (and should be 22 kN).

The Report produced by Mr P Seddon (01/550563) notes that "... discussion followed as to how the mistake could be remedied. An amendment via. the Unique Acceptance Procedure (UAP) was suggested ...".

I circulated, for information, a brief Email to this effect to Messrs. N Ratty, A East, I Britten and A Maitra (29th January 2001).

A *draft* Report was received from HSL (29th January 2001): "Investigation of Webbing Slings with Integral Energy Absorbers - Part 1, Initial Examination" (Ref. MM/00/15, Engineering Control Group).

On 29th January 2001 I met Mr I Duncan (Regional Sales Manager, Uvex (UK) Ltd.), an equipment distributor, and requested that he respond to the questions (previously sent to others) presented in Annex A.

At a Meeting of PH/5 (31st January 2001) I presented a resume, in tabular form, of the NEL Test Results and an extract from the text of the proposed OM (inviting responses by Email). It was agreed that "... In the short term Mr Thomas and Mr Crawford would collaborate to provide a UK contribution to CEN/TC160/WG2 for its next Meeting (May) ..." (Minutes, 01/560702, Dated 12th February 2001). It was also raised whether the same anomaly applies to EN 360 "Retractable type fall arresters".

Before the Meeting, Mr H Crawford indicated to me that he had written in a private capacity to Dr.-Ing Gunter Kloss (Convenor, CEN/TC160/WG2) with a question re. the adequacy of EN 355 (Letter, Dated 30th October 2000) but had received, to date, no response.

A *draft* Report was received from HSL (8th February 2001): "Investigation of Webbing Slings with Integral Energy Absorbers - Part 2, Final Report" (Ref. MM/01/03, Engineering Control Group).

Contact with DuPont - I have thus far been unable to obtain a response from DuPont, despite using their web-based help line.

Before a PSMA Meeting (11th January 2001) I met Mr A Jones, Pammenter and Petrie to pass on this results of the NEL Research, as it affected his Company's products.

After a BSI Technical Committee, B/514/24 (7th February 2001) I met a representative of the Construction Industry Training Board (Mr D Hands) and discussed some early plans that the CITB are considering for a ‘work at heights’ training and guidance video.

I met with representatives of Sala Group Ltd. (13th February, 2001, Mr B Warren, Managing Director, and Mr M Baldwin) to discuss the results of the NEL/HSL testing on their products, as well as missing labels [41] and the general issues surrounding degradation, uv-testing, etc..

I visited HSL, Sheffield on 15th February 2001 (Dr W Geary and Mr J Dutton) to examine some of the lanyards that had been tested. I also met representatives of HSL, Buxton (Mr C Wilson and Miss R Parkin) to discuss the scope of further research into the degradation of webbing.

In a telecon with Abtech Ltd. (Ms J Bullough) on 16th February 2001 lanyard safety was discussed. I met Mr D Evan, Mr D Beeley and Ms D Jamieson on 8th March 2001. Subsequently, the list of queries (Annex B) was sent by Email (12th March 2001).

END (12th March 2001)

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[41] *To date (25th July 2001) Sala Group have been unable to provide any information (e.g. dates, etc.) based on the identification numbers on attached harnesses.*

ANNEX B - MEETING WITH LANYARD MANUFACTURERS, ETC., HELD ATHSE, BOOTLE ON 7 JULY 2000

David Thomas	HSE, Technology Division HM Specialist Inspector (Construction)	(Chairman)
Nick Ratty	HSE, FOD Safety Unit HM Principal Inspector of Health and Safety	
Dave Allport	Troll Safety Equipment (Dalloz Fall Protection) Industrial Sales Manager	
Ben Lyon	Lyon Equipment Ltd. Managing Director	
Peter Blackburn	SpanSet Product Development Manager	
Wayne Ellis	Barrow Hepburn Sala Ltd. a Member of the Capital Safety Group Ltd.	
Adrian Jones	Pammenter and Petrie Regional Sales Manager	
John Anslow	Protecta International Technical and Training Sales Advisor	
Robert Weeks	RidgeGear	
Stuart Linnitt	Manager, Tractel Training Solutions representing Tractel Group Manager	

AGENDA

1. Welcome

2. Introductions

3. Purpose of Meeting

4. Discussion

   Issues of concern - Obsolescence; degradation; contaminants; conditioning, standards, provision of information, etc.

5. Legal Issues

6. Closing Remarks

7. Close of Meeting

LANYARD SAFETY - INDUSTRY MEETING

ACTION LIST FROM MEETING HELD ON 7 JULY 2000

Item	***Who***	***Action***
Respond to HSE queries, previously sent by E-mail, **additionally advising on: what you consider to be 'obsolescence'; and, what strength webbing(s) you use**	Industry	**URGENT**
Arrange date for follow-up visit(s)	D Thomas	
Consider what information is currently provided to users concerning the care, maintenance, inspection and use of man-made fibre-based material; aiming to agree a revised 'best practice' statement	**Industry**	Note - there has been a suggestion that this could be done through PSMA (Contact: Adrian Jones), with HSE (D Thomas) and possibly external input
Consider what levels of training are currently provided to those who select, use, inspect and maintain lanyards, etc.; aiming to reach agreement on the minimum content of a training course syllabus	**Industry**	
Provision of advice to HSE Inspectors	D Thomas N Ratty	This could be based on any advice produced (see above)
Send relevant information on degradation, etc. to HSE, noting whether or not it can be disseminated	Industry	
Supply HSE with an estimate of the number of energy absorbing lanyards that were sold in 1999	Industry	Note - this information will remain confidential
Supply HSE will some samples of new energy absorbing lanyards, and webbing (for possible testing)	Industry	Note - specific details of test results will remain confidential
Clarify the requirements for strength of the BS ENs (and compare to ISO)	D Thomas	Note - Contact Paul Seddon
Establish who (if anyone) represents HSE on PSMA (BSIF)	N Ratty	
Undertake testing and examination, etc. of the 40 No. energy absorbing lanyards; discussing results, as appropriate	D Thomas (HSL)	
Determine further details of incidents in Eire and Australia	D Thomas	
Ascertain details of ageing requirements in International Standards, or for similar material in other products (with different uses)	D Thomas	Note - please assist if you are able! I have a collection of Standards, but am always on the look out for others!
Date of Next Meeting:	To be advised, if required	

18th July 2000

Further to our Meeting, held at HSE Bootle on 7 July 2000, I confirm that the Health and Safety Executive (Technology Division) is undertaking an investigation into the properties, resistance and degradation of man-made fibre lanyards (inc. energy absorbers). As discussed, I would be grateful if you could respond, as a matter of urgency, to the following queries:

- Which fibres are used in your products, e.g. nylon, polyester, etc.? *(Please provide copies of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply)*
- Who supplies your fibres (and/or webbing)? *(Please provide company name, address, contact name (technical) and telephone number)*
- What information do you provide to your customers? *(Please provide copies)*
- What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?
- Can you provided any additional information on:
  - ✓ the resistance to chemicals (and, perhaps, other substances); and
  - ✓ the effect of rust and fumes?
- Have you undertaken any natural and/or artificial ageing tests? *(Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.)*?
- In lanyard/harness design, what allowance(s) do you make for:
  - ✓ light, weather and chemical degradation; and
  - ✓ 'Wear-and-tear'?
- How do you take account of the following *(please state if not applicable)*:
  - ✓ lustre and pigment (included during manufacture);
  - ✓ coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*;
  - ✓ uv inhibitors; and
  - ✓ filament denier and fibre cross-section?
- Have you evaluated the effect of:
  - ✓ moisture and temperature?
- Have any of your lanyards failed (or are you aware of any other instances)?
- Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?
- Are you able to trace product batches and link to the raw material(s)?
- Which notified body do you use for product testing?

Finally, I would be grateful if you could consider the following:

- The PPE (EC Directive) Regulations 1992 (the PPE 'Supply' Directive) requires information to be supplied by the manufacturer concerning *"... storage, use, cleaning, maintenance, servicing and disinfection ..."* and *"... the obsolescence deadline or period of obsolescence of PPE or certain of its components ..."*. Accordingly, what do you consider as 'obsolescence'?

I look forward to hearing from you and hope to arrange a meeting in the near future. Information provided will be treated in confidence. Should you require any clarification or further information please do not hesitate to contact me.

DAB Thomas HM Specialist Inspector of Health and Safety (Construction)

ANNEX C - NEL TEST RESULTS, RESUME

Specimen ID	Manufacturer	Model	ID Label Missing	Year of Manufacture	Age at Nov. 00 (Months)	General Description					Damage					Force (kN)				Type Test		Maximum Impact Force > 6 kN	Failure									Inspected Monthly	Notes	
						W/W	W/W/Steel Link	R/W	W/W/Integral	W/Abs Block	None/General	Slight	Moderate	Bad	Serious	Failure	Peak	Average Tear Out	Ave. Tear Out for Model	Pass	Fail		Interface Loop (Pack/ Lanyard)	Interface Loop (Pack/ Ring)	Absorber (Start of Tear-ply Stitching)	Tear-ply	Adj to Shrink-fit ID Sleeve	Main Webbing (160 mm from Absorber Stitchng)	Main Webbing (25 mm from Absorber Sleeve)	At Damaged Attachment Point	Below Attachment Point Stitching	Stitching Pattern at Start of Absorber Pack			
1	A	1	1			1					1						15.62	4.09		1		1													
2	A	1	1			1						1				11.45		4.12			1	1	1												
3	A	1	1			1					1						15.96	4.12		1		1	1											Machine Overrun (Load to failure 15.96kN) - Not held for 3 min.	
4	A	1		August-97	39	1						1					15.15	---		1		?		1										Recording Error (wrt tear out force)	
5	A	1	1			1						1				12.89		---			1	?	1											Recording Error (wrt tear out force)	
6	A	1	1			1						1					15.39	5.10		1		1													
7	A	1	1			1					1					13.72		3.76	4.24		1	1	1												
8	A	2	1			1							1			13.88		5.11			1	1			1										
9	A	2	1			1							1			12.17		4.00			1		1												
10	A	2	1			1						1				11.39		3.88			1	1		1											
11	A	2	1			1					1					14.72		4.13	4.28		1	1	1												
12	A	3	1				1							1		14.72		3.21			1			1											*10.49*
13	A	3	1				1								1	5.21		3.32	3.27		1			1											
14	A	4	1				1				1						15.36	3.35		1															
15	A	4		1995			1				1						15.53	3.55	3.45	1		1													
16	A	5	1					1			1						15.59	5.02		1		1													
17	A	5		August-97	39			1					1			9.64		4.70			1	1				1									
18	A	5	1					1				1					15.48	5.05		1		1													
19	A	5	1					1					1			15.00		4.86			1	1					1							Max Load, 15.42 kN - Not held for 3 mins.	
20	A	5	2					1				1				15.00		5.16			1	1				1								Max Load, 15.37 kN - Not held for 3 mins.	
21	A	5						1				1					15.32	5.70	5.08	1		1													
22	A	6		1996				1				1					15.37	4.64		1		1													
23	A	6		1991				1				1					15.36	4.67	4.66	1		1												Tear ply webbing frayed during test	
24	A	7	1	May-89	138			1			1						15.85	3.51	3.51	1														Damage to main webbing of absorber pack at stitching patterns	
25	B			November-96	48				1			1				14.36		4.43			1	1						1					1		
26	B			October-96	49				1			1				11.61		4.50	4.47		1	1						1					1		
27	C	1		September-95	62				1		1						15.84	3.97		1													1		
28	C	1		May-97	42				1		1					14.54		4.46			1	1							1				1		
29	C	1		May-97	42				1		1						15.41	4.39		1		1											1	Visible damage 25 mm from absorber pack stitch pattern	
30	C	1		July-97	40				1			1				13.86		4.04			1								1				1		
31	C	1		August-97	39				1		1					15.00		4.36			1								1				1	Not held for 3 mins.	
32	C	1		July-97	40				1		1					13.94		4.19			1								1				1		*13.89*
33	C	1		May-97	42				1			1					15.36	3.82		1													1	Scuffing 25 mm from absorber stitch pattern	
34	C	1		July-97	40				1					1		8.11		4.13	4.17		1									1			1		
35	C	2	3	May-94	78				1					1		9.69		2.60			1								1					Webbing failed 25 mm from absorber stitch pattern	
36	C	2		May-94	78				1					1		8.01		2.48			1										1			Failure possibly due to information label stitching	
37	C	2		April-94	79				1					1		9.70		2.71			1											1			
38	C	2	4	June-94	77				1					1		7.29		2.42	2.55		1										1			Failure possibly due to information label stitching	
39	D			1997	3					1		1					15.33	6.54	6.54	1		1													
40	E		2							1	1					8.86		2.90	2.90		1										1				

ID Label Missing	
1	Missing
2	Illegible
3	Pen, No Label
4	Part Illegible

Summary:

< 6 kN	1
6 to 9.99 kN	7
10 - 14.99 kN	13
> 15 kN	3
Total	**24**

Totals:

	Pass	Fail	Maximum Impact Force > 6 kN
Web	10	21	**22**
Rope	6	3	
Total	**16**	**24**	40
	40.0%	60.0%	

Key:
1 Monthly, by an authorised person

DABT/26 March 2001

Key:

A	BH Sala	W/W	Webbing Lanyard/Webbing Absorber
B	Marling Leek Ltd.	W/W/Steel Link	Ditto, attached via Steel Link
C	Pammenter and Petrie	R/W	Rope Lanyard/Webbing Absorber
D	SpanSet	W/W/Integral	Webbing Lanyard with Integral Webbing Absorber
E	Komet	W/Abs Block	Webbing Lanyard feeding through Absorber Block

ANNEX D - RESUME OF HSL FINDINGS

- HSL **Report (Part 1)** [42] - Forty lanyards (both webbing and rope) with energy absorbers have been catalogued and examined visually for signs of damage that may present a safety hazard.

- A photographic record of the lanyards in the 'as received' condition has been made.

- The majority of the lanyards showed minor wear and abrasion damage.

- Fourteen lanyards had more extensive areas of wear and abrasion damage. Primarily at absorber/lanyard/connector interfaces.

- Any area of damage was photographed to allow a post-test assessment of the contribution of the damage to any subsequent failure.

- The lanyards showed evidence of dirt and dust that may present an additional external/internal wear mechanism.

- HSL **Report (Part 2)** - No absorber permanently extended at loads less than 2 kN braking force requirement, as specified in the British Standard, BS EN 355 (Clause 4.4, Dynamic Performance [43]).

- One lanyard/absorber failed below the 6 kN braking force requirement, as specified in the British Standard, BS EN 355 (Clause 4.4, Dynamic Performance).

- 55% of the absorbers peak braking force exceeded the Standard's maximum of 6 kN (Clause 4.4, Dynamic Performance).

- The average pullout force of one absorber exceeded the maximum braking force of 6 kN as specified in the British Standard, BS EN 355 (Clause 4.4, Dynamic Performance).

- Only 35% of the tested lanyard/absorbers passed the British Standard static test requirements of attaining and holding 15 kN for three minutes (Clause 5.3, Static Strength Test).

- 50% of the Pammenter and Petrie Ltd lanyard/absorbers failed in the same region, i.e. 25 mm from the stitch pattern between the absorber and the lanyard. This appeared to be associated with damage caused by the end of the absorber protective casing.

- 41.7% of the BH Sala Ltd lanyard/absorbers failed at the interface loop between the absorber and the lanyard, or the absorber loop and the screwlink connector.

- The debris analysed contained elements consistent with those expected to occur in an industrial environment.

- The size and type of particles found could cause degradation of the lanyards/absorbers by abrasion of their fibres.

- Chemical degradation mechanisms may be operative. However, these have not been assessed in detail within this investigation.

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[42] *All of the used lanyard/absorbers were subjected to the tensile static test as defined in British Standard, BS EN 355 (Clause 5.3, Static strength test).*

[43] *The 6 kN requirement comes from a dynamic performance requirement (rather than the static tests undertaken) - the relationship between the two (if any) is not clear.*

ANNEX E - DRAFT OPERATIONAL CIRCULAR(OC)

Health and Safety Executive		Operational Circular	
Field Operations Directorate		**OC 282/29**	
Cancellation Date	**For FOD SIU use**	**Open Government Status**	**Partially Open**
Version No & Date	**For FOD SIU use**	**Author Unit/Section**	**FOD Safety Unit**

To
SG Specialist Inspectors (Con, MechBands 0-3)
AFQ and RI Inspectors (Bands 0-4)
HID Inspectors (Bands 0-4)
NSD Inspectors (Bands 0-3)

DRAFT

INSPECTION OF ENERGY ABSORBING LANYARDS MADE FROM WEBBING OR ROPE

This OC advises inspectors on appropriate action with regard to inspection regimes for energy absorbing lanyards, used as part of personal protective equipment for protection against falls from height, where they are made from webbing and rope. It does not cover non-energy absorbing lanyards or other equipment such as harnesses attached to the lanyard and anchor points, although many of the principles can be applied to non-energy absorbing lanyards and safety harnesses used as protection against falls from height. It does not cover other provision and use requirements.

Introduction

An energy absorbing lanyard (hereafter referred to as a lanyard) is a line for connecting a full body harness to an anchorage point with an in-built device that reduces the impact of a fall.

There is a wide range of possible causes of degradation of man-made fibres used in webbing and rope lanyards (including abuse, general wear and tear, edge/surface damage, ultraviolet light, dirt, grit, chemicals).

BS EN 365:1993 *Personal protective equipment against falls from a height. General requirements for instructions for use and for marking* (under revision) gives general requirements for periodic inspection, instructions for use and marking of PPE against falls from a height. To counter the causes of degradation described in paragraph 2, the British standard states that components should be examined "**at least** twelve monthly". This is sometimes taken to be "annually", although manufacturers of textile products usually recommend inspection more frequently than this.

Recent research by Health and Safety Laboratory (HSL) involving man-made fibre webbing and rope lanyards has confirmed the range of causes of degradation and highlighted that there is no well defined boundary (e.g. usable life) separating those lanyards which are safe and those which are not. Therefore lanyards need to be subject to an effective inspection regime, to maintain their safety for use as protection against falls. The paragraphs below give recommendations for the frequency and type of inspection which may be needed.

Inspection Regime

The inspection regime recommended in this OC has been discussed with representatives of manufacturers, suppliers, installers and major users via British Standards Institution Technical Committee PH/5 *Industrial safety belts and harnesses* and the Personal Safety Manufacturer's Association *Height and Access Committee* (PSMA).

Duty holders should establish a regime for the inspection of lanyards which should include: the lanyards to be inspected; the frequency and type of inspection (pre-use checks, detailed inspection and where appropriate interim inspection); who will carry out the inspections; action to be taken on finding defective lanyards; training of users and competent persons to carry out the inspections. Duty holders should also consult manufacturers' instructions.

It is essential that the person carrying out any inspection is sufficiently independent and impartial to allow objective decisions to be made, and has appropriate and genuine authority to discard defective lanyards. This does not mean that competent persons must necessarily be employed from an external company, although many manufacturers and/or suppliers offer inspection services and training in the inspection of their products.

Duty holders may wish to provide additional lanyards to use as replacements in the event that defective lanyards have to be taken out of use.

Special consideration may need to be given to lanyards which are on hire, to ensure that they are subject to detailed inspections (and interim inspections if appropriate) within the period specified in the regime. Hirers should be informed of any use or damage which may affect the safety of the equipment (e.g. use with chemicals).

Scope of the Inspection Regime

Lanyards should be subject to:

- pre-use checks;
- detailed inspections; and
- (as appropriate) interim inspections;

to identify defects or damage affecting safety.

Pre-use Checks

These should be carried out each time before the lanyard is used. These checks are essential and may be best done by the person who will use the equipment. The person doing the checks must be competent to do them.

Pre-use checks should be tactile and visual. The whole lanyard should be subject to the check, by passing it slowly through the hands (e.g. to detect softening or hardening of fibres, ingress of contaminants). A visual check should be undertaken in good light and will normally take a few minutes.

Detailed Inspections

These are more formal in depth inspections which are carried out periodically at minimum intervals specified in the duty holder's inspection regime. The inspection regime should be drawn up by a competent person. Detailed inspections should be recorded. It is recommended that there is a detailed inspection at least every six months. For frequently used lanyards it is suggested that this is increased to at least every three months, particularly when used in arduous environments (e.g. demolition, steel erection, scaffolding, steel skeletal masts/towers with edges and protrusions).

Interim Inspections

These are in depth inspections and may be appropriate in addition to pre-use checks and detailed inspections. Interim inspections are those which are required to be carried out between detailed inspections because the duty holder's risk assessment has identified risks that could result in significant deterioration affecting the safety of the lanyard before the next due date of the detailed inspection. Whether interim inspection needs to be carried out will depend on use, as will the frequency of any interim inspections necessary. Examples of situations where interim inspections may be appropriate include risks from transient arduous working environments involving paints, chemicals or grit blasting operations; or acidic or alkaline environments if the type of fabric the lanyard is made from cannot be determined (some fabrics offer low resistance to acids or alkalis). Interim inspections should be recorded.

Examples of Defects and Damage

The following defects and damage have the potential to result in the degradation and/or weakening of the lanyard:

- a knot in the lanyard, other than those intended by the manufacturer;
- surface abrasion across the face of the webbing and at the webbing loops, particularly if localised;
- abrasion at the edges, particularly if localised;
- cuts to the webbing, rope or stitching, particularly at the edges (e.g. where the lanyard may have been choke hitched around steel work);
- chemical attack can result in local weakening and softening - often indicated by flaking of the surface. There may also be a change to the colour of the fibres;
- heat or friction damage indicated by fibres with a glazed appearance which may feel harder than surrounding fibres;
- damaged or deformed fittings (e.g. karabiners, screwlink connectors, scaffold hooks);
- UV-degradation which is difficult to identify, particularly visually, but there may be some loss of colour (if dyed) and a powdery surface;
- partially deployed energy absorber (e.g. short pull-out of tear webbing);

- contamination (e.g. with dirt, grit, sand etc) which may result in internal or external abrasion.

Other Factors

Any lanyard that has been used to arrest a fall should never be re-used. It should be withdrawn from service immediately and destroyed.

All lanyards should be indelibly and permanently marked (BS EN 365:1993). They should be uniquely identifiable so that they can be easily associated with their respective inspection documentation.

Action by Duty holders

Lanyards should be withdrawn from use and passed to a competent person for a detailed inspection to decide whether they should continue to be used or destroyed if:

- there is no evidence that a lanyard has been inspected by a competent person within the last six months;
- identification is not evident;
- a lanyard is still in use and marked to the old British Standard, BS 1397: 1979 *Specification for industrial safety belts, harnesses and safety lanyards* (i.e. pre CE-marking);
- after a pre-use check or interim inspection, a lanyard is thought to be defective, or if there is any doubt about its safety.

Action by Inspectors

In cases where there is doubt about the frequency of inspections specified in an inspection regime, inspectors should consult Divisional Specialist Group (SG) Civil Engineering Speciaist Inspectors.

EMM Guidance

[OMITTED]

Date first issued:

[DRAFT 31 March 2001]

ANNEX F - HSL DROP TESTS

Industrial Safety Harness Tests with Anthropometric Dummy

Summary of Results

Test	*Fall factor*	*Maximum impact force (kN)*		
		Energy absorbing lanyard	Rope	Steel strop
Fully Body Harness (FBH) on Anthropometric Dummy	FF1	5.9	7.8	16.1
	FF2	6.1	10.5	22.1
100 kg Test Mass	FF1	4.4		
	FF2	7.4 *		
* Note: Front attachment (all others were rear attachment)				

Abbreviations

FF Fall Factor

Testing undertaken by HSL
(Report Reference, FE/00/01, Dated 15th December 2000)

DAB Thomas
SI, TD2
x3322

ANNEX G
TENSILE TESTS ON SOME WEBBING SAMPLES

Results of Tests on 'RidgeGear' Webbing, 24th July 2000

Test no.	***Item***	***Test***	***Tensile strength (kN)***	***Failure***
1	*RidgeGear* - 'Soft Edge' Webbing (Purple)	New	39.45	'Tufted'
2		Ditto, but with the addition of an overhand knot	14.61	'Clean' failure at knot (45 degrees), i.e. a reduction of **63.0 %**
3		New, but with an edge 'nick' to the line of black stitching (about 3 mm)	31.23	Failure mode similar to Test 1 - a reduction of 20.8 %
4	*Marling Leek* - Standard 25 mm Harness Webbing (Black)	New	24.27	'Tufted' (and at a 45 degree angle, approx.)
5		Ditto, but with the addition of a small edge 'nick'	18.36	Different from other failures - very 'tufted', with the failure being progressive (i.e. a reduction of 24.4%).

DAB Thomas
SI, TD2
X3322

ANNEX H

RESUME OF INFORMATION PROVIDED BY MANUFACTURERS, ETC.

Sala Group Ltd.

Lyon Equipment Ltd.

RidgeGear

SpanSet

Protecta

Pammenter and Petrie

Dalloz Fall Protection

Tractel Training Solutions

Sala Group Ltd. (Email, Rcd. 7th July 2000) - Tony Hamer

Which fibres are used in your products, e.g. nylon, polyester, etc.?	The majority of Sala Group's webbing products are manufactured from polyester. Rope lanyards are manufactured from 12 mm 3 strand nylon. The minimum breaking strength (MBS) of the webbing used in harnesses is 3.4 tonnes. The rope and webbing used in lanyards have an MBS of 3 tonnes.
Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply	
Who supplies your fibres (and/or webbing)?	Webbing mainly supplied by Samual Roche (France). Tel. No.: 0033-477-57-2455. Rope is supplied by Marlow Ropes Tel.: 01323-847-234.
Please provide company name, address, contact name (technical) and telephone number	Samual Roche Technical Rep. (UK), Mr Ian Spicer, Tel.: 01538- 384-380. Marlow Ropes - Contact: Mark Durbidge.
What information do you provide to your customers?	
Please provide copies	
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	Advise that harnesses have at least an annual inspection, and a quick visual check before use. Offer a course on the inspection of Sala harnesses, and back this up with documentation.
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	Re. coatings, uv-inhibitors, ageing tests, etc.: "... we are trying to obtain some detailed information to help in your investigation ... believe that our sister company in the USA have carried out an investigation into this subject ... will also try and obtain [44] some information from our webbing manufacturers ...".
Have you undertaken any natural and/or artificial ageing tests?	
Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	
How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	
Have you evaluated the effect of: moisture and temperature?	
Have any of your lanyards failed (or are you aware of any other instances)?	Not aware of any incidents where one of our lanyards have failed.

[44] *No further information received.*

Cont./...

Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	Offer the service of inspecting customers' lanyards, but this is not on a planned basis where we contact the customer and inform him that equipment is due for inspection. Some customers do return their equipment on a regular basis for inspection. The condition of the equipment returned can vary enormously. On average faults are found in 1-in-3 items returned. A record of the faults found on equipment is kept (and the records are available for review).
Are you able to trace product batches and link to the raw material(s)?	There is complete traceability on the materials used in the manufacture of products, back to suppliers. Batch numbers are allocated to the materials when they are booked in during the 'Goods Inwards' process. These stay with the materials; in the stores and when they are picked to produce a batch of lanyards, etc.. The batch reference numbers are recorded on the 'Production Route Card'. All webbing is tensile tested during the 'Goods Inward' process, and the results are recorded against the batch number.
Which Notified Body do you use for product testing?	Mainly use NEL at East Kilbride for product testing.
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992)	

Notes:

For a resume of some further information supplied by the Capital Safety Group Ltd. (of which Sala is a Member) refer to Section 5.

Contact Details:

Sala Group Ltd.,
Old Mill Road,
Portishead,
Bristol,
BS20 7BX.

Tel.: 01275-846-119.

Lyon Equipment Ltd. (Letter, dated 25th August 2000) - Jonathan Capper

Which fibres are used in your products, e.g. nylon, polyester, etc.?	Tape: 25 mm (+/- 1 mm) nylon tape webbing, Minimum rating 20 kN EN 565: 1993. Shrink sleeve: 38 mm dia. Polyolefin heat shrinkable tubing (50% shrinkage at 130^{o}C). Sewing thread: Bonded nylon thread, Size M20 (BS 6157).
Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply	
Who supplies your fibres (and/or webbing)?	Tape: Beal Sleeve: William Kenyon Sewing Thread: Oxley Threads Ltd.
Please provide company name, address, contact name (technical) and telephone number	Beal, 2, Rue Rabelais, BP 325, F38201, Vienne, France. William Kenyon, PO Box 33, Chapel Field Works, Duckinfield, Cheshire. Oxley Threads Ltd., Guide Mills, South St., Ashton-under-Lyne, Lancashire.
What information do you provide to your customers?	Enclosed: 'User instructions for energy absorbing lanyard' (4 pp); Petzl Technical Information (3 pp and 1 pp); 'Care of Your Equipment (Lyon Equipment, Appendix 7)'; User Instructions for Climbers Sling to EN 566.
Please provide copies	
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	Limited information is available from raw material suppliers.
Have you undertaken any natural and/or artificial ageing tests?	No.
Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	Utilise metal components made from 316 Stainless Steel. Covering moving parts with a protective sheath. Covered load bearing webbing components with a protective sheath. Protected product name, user information, batch number, manufacturer with clear protective sheath.
How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	Not taken into consideration, except coatings, dyes, finishes, etc. are performance tested to EN 355.
Have you evaluated the effect of: moisture and temperature?	Performance tested to EN 355.
Have any of your lanyards failed (or are you aware of any other instances)?	Not aware of any to date.
Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	Not on a planned basis. However, a full inspection service is offered, inc. visual, proof and destructive testing.

Cont./...

Are you able to trace product batches and link to the raw material(s)?	Yes.
Which Notified Body do you use for product testing?	SGS Yardsley (Reg. No. 0120), Gaw House, Alperton, Wembley, London.
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992)	Textiles have a maximum lifespan of 5 years, except ropes which may only be 3 yrs. Clear and unambiguous instructions must be provided by the manufacturer to ensure that the user can inspect and maintain the item of ppe.

Notes:

For a resume of further information provided by Lyon Equipment Ltd. refer to Section 5.

Contact Details:

Lyon Equipment Limited,
Rise Hill Mill,
Dent,
Sedbergh,
Cumbria,
LA10 5QL.

Tel.: 015396-25493.

RidgeGear (Letter, dated 2nd November 2000) - Robert Weeks

Which fibres are used in your products, e.g. nylon, polyester, etc.?	100% polyester fibres in range of safety harnesses. Lanyards are also manufactured from polyester yarns, although the tear webbing inside the shock absorber is currently manufactured from a mix of polyester and nylon (in order to give the correct tear out forces due to the varying elongation properties).
Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply	Company literature folder provided ('One Company').
Who supplies your fibres (and/or webbing)?	Marling Leek, Marling Mills, Nelson Street, Leek, Staffordshire, ST13 6BB.
Please provide company name, address, contact name (technical) and telephone number	Kevin Holroyd (as above), Tel.: 01538-384-108.
What information do you provide to your customers?	
Please provide copies	
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	Re. chemical resistance - Refer to 'Tensile Properties of Filament Yarns' (ICI, Pages 2.22 to 2.27) and 'Chemical Properties of Terylene and ICI Nylon' (Pages 2.31 to 2.310); and 'Technical Information' for Trevira [45] High Tenacity (Pages 4 to 38) [46]. No specific data is available in regard to rust [47]. Things such as cement dust, concrete, etc. "... are potentially more worrying ..." (and it was suggested that some testing could be carried out). Fumes - Refer to 'Trevira' Information (Page 17) - Standard ATS 1000.001 (Aviation Smoke and Toxicity Test) - against which webbings have been tested (and all passed).
Have you undertaken any natural and/or artificial ageing tests?	See 'Notes' (below).
Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	Following a Meeting with HSE on 24th July 2000, some uv degradation testing was arranged on the purple 'soft edge' webbing (51009-707).
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	Allowances are made for degradation by using "... A ladder type weave with a tight construction to improve abrasion resistance, and also use metal fittings with none abrasive webbing slots with rounded edges ...".

[45] *'Trevira high tenacity' is a high strength filament yarn made from polyethylene glycol terephthalate and has a high resistance to a wide range of chemical products.*

[46] *Also obtained (24th July 2000) was a copy of 'Motor Vehicle Safety Standard No. 209 - Seat Belt Assemblies' - which gives requirements for resistance to abrasion and resistance to light (carbon arc).*

[47] *Mr Holroyd (Marling Leek, for RidgeGear) noted that he would start some testing by wrapping three samples (say) around an unplated metal bar (which will corrode) and leave them outdoors for three, six and nine months respectively. Then, after each exposure cycle, load and break each one to establish the retained strength.*

Cont./...

How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	Extra allowance for degradation is made, e.g. use of dispersal dye (automotive seat belt type dying process): "... this reduces the level of abrasive particles as the fibres are thermofix together at approx. 210ºC. Additionally we apply a water, oil and stain repellent treatment to the webbing ...".
Have you evaluated the effect of: moisture and temperature?	Moisture and temperature information is available for the yarn (Ref. ICI Information, Page 2.24). Lanyard webbing has been subjected to 100ºC and left for 24 hrs (with no loss in strength). Also, a sample has been left in water for 24 hrs and tested wet (with no loss in strength).
Have any of your lanyards failed (or are you aware of any other instances)?	Do not know of the failure ever of a lanyard.
Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	Do not inspect lanyards as a matter of course, although RidgeGear offer technical support. The instructions for use specify that harnesses and lanyards are examined before each use, and the webbing be checked for evidence of abrasion, cuts, holes or burns. Have no information on the quantity of rejected or lanyards put to quarantine.
Are you able to trace product batches and link to the raw material(s)?	All webbing inspection records are fully traceable back to all the tests made on that particular batch of webbing. Such records are then traceable back to the raw yarn supply and the goods receipt of the raw yarn fibre. A system of linking a harness and lanyard serial number back to the exact batch of all the raw material components (inc. metal fittings) is being introduced.
Which Notified Body do you use for product testing?	NEL, East Kilbride.
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992)	

Notes:

For a resume of further information supplied by RidgeGear, refer to Section 5.

Contact Details:

RidgeGear Limited,
Nelson Street,
Leek,
Staffordshire,
ST13 6BB

Tel.: 01934-876-081.

SpanSet (Letter, dated 10th October 2000) - Peter Blackburn

Which fibres are used in your products, e.g. nylon, polyester, etc.?	Polyester and nylon.
Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply	Ref. ICI Technical Information 'General Properties' [48]. This covers ICI Nylon and Terylene (Polyester).
Who supplies your fibres (and/or webbing)?	William Kenyon & Sons (Ropes and Narrow Fabrics) Ltd.
Please provide company name, address, contact name (technical) and telephone number	William Kenyon & Sons Duckinfield SK14 4RP Tel.: 0161-308-6000 Contact: Keith Hadfield
What information do you provide to your customers?	Provided information sheets on the 'T-Pak' Lanyard and 'Lite' Harness.
Please provide copies	
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	Ref. 'Inspection and Examination' on the information sheets (see above). SpanSet recommends recorded inspection by a competent person every four months.
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	Refer to ICI Report (see above).
Have you undertaken any natural and/or artificial ageing tests?	No such test performed to date. SpanSet manufacturers height safety equipment in Australia - they are in talks with them to acquire data on uv ageing of webbing safety equipment.
Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	Any point on a harness, or lanyard, can have additional wear material added to increase its useful life, i.e. leather wear protection on shoulders of a harness for a scaffolder, or pvc wear sleeve in lanyards. However, "... As the manufacturer the above allowances can not be guaranteed as we can not foresee what environments they may be used in ...".
How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	Lustre and pigment: No affects, of coloured web. Coatings, etc.: The majority of the webbing is piece dyed. Uv: ---- Filament denier, etc.: Not applicable.
Have you evaluated the effect of: moisture and temperature?	No.
Have any of your lanyards failed (or are you aware of any other instances)?	Know of no occasions of a SpanSet failing in use.

[48] *This is similar to the information provided by RidgeGear (but a different version). William Kenyon note that ICI no longer supply yarn - the polyamide business was taken on board by DuPont (who still supply them) and the polyester was taken on by Celanese (who are thought to be part of Hoecsht). Polyester is sourced from an alternative supplier.*

Cont./...

Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	SpanSet runs care, use and maintenance course ('Notes' provided) - on qualification they are deemed to be a 'competent' person. SpanSet inspects some used harnesses and lanyards - this can result in items being scrapped. "... It is impossible tom indicate the percentage scrapped, in some instances 10 out of 10 need scrapping, on other occasions it can be 1 out of 10, or none. It is dependent on what industry they are used in ...".
Are you able to trace product batches and link to the raw material(s)?	No "... we relate to a material specification ...".
Which Notified Body do you use for product testing?	SATRA (and, occasionally, NEL).
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992)	

Notes:

None.

Contact Details:

SpanSet,
Telford Way,
Middlewich,
Cheshire,
CW10 0HX.

Tel.: 01606-737-494.

Protecta (Letter, dated 17th November 2000) - Paul Farr

Which fibres are used in your products, e.g. nylon, polyester, etc.?	Polyamide (>20 kN).
Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply	Ref. Technical Specification Sheet, AE529 & /1 Lanyards.
Who supplies your fibres (and/or webbing)?	Protecta International SA
Please provide company name, address, contact name (technical) and telephone number	Protecta International SA Zone Industrielle 5eme Avenue - BP15 06511 Carros Cedex Nice France Tel.: 00-33-497-100-010 Fax.: 00-33-493-087-970
What information do you provide to your customers?	Protecta supplies all products with use and maintenance instructions.
Please provide copies	Ref. Instructions for 'Sanchoc' Lanyard.
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	At present, do not have any specific information regarding the effects or resistance to chemicals, rust, fumes or uv degradation. It is understood that trials are in progress in their 'R and D' Establishment (USA).
Have you undertaken any natural and/or artificial ageing tests?	
Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	Cannot give specific details of 'design allowance' - will need to refer to design and development department at Protecta. However "... their designs will be based upon the requirements of EN 355 ... there is little or no reference to many of the points you raise in the EN Standards ...".
How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	
Have you evaluated the effect of: moisture and temperature?	No specific tests regarding moisture and temperature.
Have any of your lanyards failed (or are you aware of any other instances)?	Not aware of any lanyard failures in the UK.
Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	Not on a planned basis. However, when they do such inspections the 'wear and wear' can vary significantly. Generally, however, there are relatively few items that are condemned.

Cont./...

Are you able to trace product batches and link to the raw material(s)?	Under ISO 9001 can offer full traceability back to raw material.
Which Notified Body do you use for product testing?	APAV Grenoble, France
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992)	

Note:

A copy of the Protecta 'Fall Protection' Training Notes was also provided (7th July 2000).

Contact Details:

Protecta International,
Protecta House,
Unit 3, Seymour Court,
Manor Park,
Runcorn,
Cheshire,
WA7 1SY.

Tel.: 01928-571-324.

Pammenter and Petrie (Letter, dated 6th October 2000) - Adrian Jones

Which fibres are used in your products, e.g. nylon, polyester, etc.?	Nylon in lanyards (MBS 24 kN). Polyester in harnesses (MBS 22.75 kN). 'Certificate of Conformity' supplied for each.
Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply	
Who supplies your fibres (and/or webbing)?	Ribbons Ltd.
Please provide company name, address, contact name (technical) and telephone number	Treorchy Industrial Estate Treorchy Mid Glamorgan South Wales CF42 6EJ Tel.: 01443-432-473 Fax.: 01443-437-413 Contact: Mr Wayne Morse
What information do you provide to your customers? *Please provide copies*	Ref. 'User Manual - P+P Belts, Harnesses & Ancillary Equipment', 'Fitting Instructions' (Harness) and 'User Instructions' (Energy Absorbing Lanyard).
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	Visual check before each use and a recorded inspection at least every 3 months.
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	No specific information is included in the Manual. However, "... We can take up specific potential chemical contaminates with our webbing manufacture ...". Refer to 'General Properties of Nylon 6.6' for 1027/N Fibre (DuPont, Pages 8.9 to 8.15) and 'Behaviour of Rope Yarns' (Shirley Institute Bulletin, 1981, 55(1), Pages 2 to 7, FB 1601-76).
Have you undertaken any natural and/or artificial ageing tests?	No, but from time to time to time harnesses and lanyards are returned from users and tested to the Standard performance requirements.
Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	No specific allowances are made for light, weather, chemical degradation and wear and tear, other than to use quality made webbing which meet or exceed the requirements of the EN.

Cont./...

How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	Not specifically taken into account. Lanyard webbing does contain an uv inhibitor, which is put in the yarn. Ref. 'Product Data Sheet' (DuPont) re. Filament denier and fibre cross section - Dtex 940, Fils 140, Type 728(R20).
Have you evaluated the effect of: moisture and temperature?	Information can be provided, upon request "... happy that (the lanyards) are suitable for the environments in which we sell our products ...".
Have any of your lanyards failed (or are you aware of any other instances)?	Never had a lanyard fail in 20 yrs. Are aware that the product has arrested falls, with no problems.
Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	Inspect customers' lanyards as and when requested (not, currently, on a contract or regular basis). All forms of wear and tear from, cuts, nicks, burns and heavy chemical contamination source often identifiable, through to damage of the connectors. Suggest that around 20% of harnesses/lanyards fail their inspections.
Are you able to trace product batches and link to the raw material(s)?	Yes.
Which Notified Body do you use for product testing?	NEL, East Kilbride and SATRA, Kettering.
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992).	

Notes:

Refer to Section 5 for details of further information supplied by P and P.

Contact Details:

Pammenter and Petrie,
131, New John Street,
Aston,
Birmingham,
B6 4LD.

Tel.: 0121-359-2271.

Dalloz Fall Protection (Memo, undated) - Dave Allport

Which fibres are used in your products, e.g. nylon, polyester, etc.?	Nylon (Absorbers, Average Tear 5 kN) and Polyamide Webbing (25 mm, > 22 kN).
Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply	
Who supplies your fibres (and/or webbing)?	Ribbons Ltd.
Please provide company name, address, contact name (technical) and telephone number	Treorchy Industrial Estate, Mid Glamorgan, South Wales, CF42 6EJ.
What information do you provide to your customers?	
Please provide copies	
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	Provided notes from Miller Dalloz Training 'Fall Protection Equipment Inspectors Course'.
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	Also, ref. Troll 'Tapes, Slings and Harnesses' by Dr. Andy Perkins [49].
Have you undertaken any natural and/or artificial ageing tests?	Ref. 'User's Guide - Lanyards for Industrial Safety' and 'Slings - Important Information ...'.
Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	
How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	
Have you evaluated the effect of: moisture and temperature?	
Have any of your lanyards failed (or are you aware of any other instances)?	Used lanyards provided, for testing.
Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	
Are you able to trace product batches and link to the raw material(s)?	
Which Notified Body do you use for product testing?	
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992)	

[49] *'A Guide to the Selection, Use and Care of your Tape Equipment from Britain's Wizard on Web'.*

Notes:

'A Guide to the Selection, Use and Care of your Tape Equipment from Britain's Wizard in Web' includes detailed information on: The Theory of Fall Factor; Troll Tape (Basic Material, Weaving, Tape Construction, Width and Strength; Yarn Treatment; Dyeing; Heatsetting; Web Strengths; Stitching; Tape Deterioration; Misuse; Shock Absorbing Slings; Harnesses); and, The Do's and Don'ts of Web Care.

Refer to Section 5 for details of further information supplied by Troll Safety Equipment (Dalloz Fall Protection).

Contact Details:

Dalloz Fall Protection,
Spring Mill,
Uppermill,
Oldham,
OL3 6AA.

Tel.: 01457-878-822.

Tractel Training Solutions (Parcel, Rcd. 25th October 2000) - Stuart Linnitt

Which fibres are used in your products, e.g. nylon, polyester, etc.? *Please provide copie(s) of brochure(s) and/or technical information for any lanyards and/or harnesses that you manufacture and/or supply*	Lanyards - 12 mm dia. Polyamide, 11 mm dia. Semi-static rope (EN 1891) or 30 mm polyester webbing. High tenacity (HT) 1000 denier and 1500 denier polyester (harness and lanyard webbing). Mixture of HT polyester and HT Nylon for energy absorber pack.
Who supplies your fibres (and/or webbing)? *Please provide company name, address, contact name (technical) and telephone number*	Samual Roche 3, Rue de la Corre, F 42030, St Etienne, France. General Manager: Christian Roche Tel.: 00-33-4-77-57-24-55 Fax.: 00-33-4-77-80-53-21 Different suppliers supply the yarn, inc. Allied, Acordis, Kolon
What information do you provide to your customers? *Please provide copies*	Provided comprehensive Tractel 'Safety by Tractel' Product Literature Folder.
What advice do you provide to customers concerning the inspection, examination and maintenance of your lanyards and/or harnesses?	Notes on 'Inspection Scheduling' (Page 12 to 24, inc.): harness inspection procedure, rope and tape products. Avoid abrasion, friction of webbing on a rough surface.
Can you provided any additional information on: the resistance to chemicals (and, perhaps, other substances); and the effect of rust and fumes?	The 'Notes' (see above) state that "... both nylon and polyester are susceptible to damage by heat ... neither should be exposed to temperatures in excess of 50ºC ... if a length of material has come into contact with an unknown chemical or contaminant then it should be discarded [50] ...".
Have you undertaken any natural and/or artificial ageing tests?	The 'Notes' (see above) state that "... oil based fabrics such as nylon and polyester are effected adversely by prolonged exposure to sunlight (nylon can lose 4% of its overall strength after 300 hrs of exposure to British sunlight ...". White webbing (which has not been coloured) exposed for 3 yrs in the Roche Laboratory has lost 7% of its strength, the same webbing stored indoors (and not exposed to natural light) has lost 6% of its strength. Colour protects the webbing from the light, esp. 'Chambon' Process.

[50] *For general reference, the following applies: Nylon - low resistance to acids and high resistance to alkali (and Polyester, visa-versa).*

Cont./...

Please provide a resume, if possible, e.g. location for natural ageing, light source for artificial ageing, etc.?	
In lanyard/harness design, what allowance(s) do you make for: light, weather and chemical degradation; and 'wear-and-tear'?	When exposed to weather, rain, sun, temperature, the loss of strength is increased (i.e. 46% in 3 yrs for white webbing; and 32% in 3 yrs for coloured webbing).
How do you take account of the following *(please state if not applicable)*: lustre and pigment (included during manufacture); coatings, dyes, finishes, etc. *(state whether used and what the dying process is)*; uv inhibitors; and filament denier and fibre cross-section?	
Have you evaluated the effect of: moisture and temperature?	Materials should not be used unless protected by an anti-uv process.
Have any of your lanyards failed (or are you aware of any other instances)?	
Do you inspect your customers' lanyards on a planned basis (if 'yes', what 'wear and tear' do you typically encounter - and what proportion need to be 'quarantined')?	
Are you able to trace product batches and link to the raw material(s)?	
Which Notified Body do you use for product testing?	
Accordingly, what do you consider as 'obsolescence'? (Ref. the PPE (EC Directive) Regulations 1992)	

Notes:

Extract from **Fax.** (10 October 2000, F Timmermans to S Linnitt):

"... Polyester webbing is used because of its good resistance to light and temperature ... Webs are coloured, either piece-dyed (by running through a dyeing range after being woven) or spun-dyed black (the yarn is coloured black during the spinning process by the addition of carbon pigments - this is a very efficient protection 'Chambon' process) ... No coating or finishing is totally efficient in the long-term because of wear and abrasion. Uv-inhibitor will not be more efficient than a proper dyeing for polyester. Filament denier will have no effect on the durability of the web, but using yarns with a very high filament count will increase the abrasion on the finished web - suggest no more than 210 filaments for a 100-denier yarn ...".

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ANNEX I - FALL ARREST EQUIPMENT AND LOLER

The Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) do not specifically require the testing, thorough examination, etc. of fall arrest equipment and systems. However, the appropriate British and European Standards do (often) give some advice. General duties under the Health and Safety at Work, etc. Act 1974 (HSWA) are considered to require some form of procedure(s) for periodic checking, as well as maintenance, etc..

If fall arrest equipment and systems are used in a workplace, the Workplace (Health, Safety and Welfare) Regulations 1992 will probably apply, in particular Regulation 13 (Falls or falling objects). Equipment provided for this purpose is required by Regulation 5 (Maintenance of workplace, and of equipment, devices and systems) to be maintained (i.e. in an efficient state, in efficient working order and in good repair, etc.) and, where appropriate, subject to a suitable system of maintenance (i.e. regular maintenance, remedy potentially dangerous defects, prevent access to defective equipment, keep suitable records, etc.).

The ACoP (Para. 22) states that regular maintenance includes - as necessary - inspection, testing, lubrication and cleaning, and should be carried out at suitable intervals. In addition, the ACoP (Para. 23) includes "... fencing and anchorage points for safety harnesses ...". in the list of equipment and devices which require a system of maintenance.

The frequency of regular maintenance - and precisely what it involve - will depend upon the equipment or device concerned, the likelihood of defects developing, the foreseeable circumstances, the age of the equipment, how it will be used (and how often), the manufacturer's information and instructions, trade literature, etc. (Para. 24). To conclude, testing (as appropriate), thorough examination *(or, detailed inspection)*, etc. would certainly be good practice and, arguably, would, as a minimum, be required under HSWA.

Note:

Advice discussed with FOD Safety Unit (Mr D Willis).

ANNEX J - FURTHER DETAILS OF THE DUPONT BULLETINS

Wave Length

Tests and experience (DuPont) indicate that ultraviolet rays with wave lengths of 290 to 400 millimicrons are the primary cause for radiation damage to fibre products. Radiation with wave lengths above 400 millimicrons, i.e. the visible and infra-red rays, can cause an increase in fibre temperature that may either accelerate ultraviolet degradation or cause heat degradation. However, these longer light waves are usually a minor cause of fibre deterioration. Radiation with wave lengths of less than 290 millimicrons, e.g. gamma and x-rays, is seldom encountered by fibre products.

Spectral Distribution

The spectral distribution of radiation within the range of 290 to 400 millimicrons is also an important factor in the deterioration of fibres by light. Some fibres are damaged principally by radiation at the lower end of the ultraviolet range, while others are affected to a greater degree by radiation at the higher end of the ultraviolet range. This phenomenon is of practical significance since ordinary window glass will not transmit the shorter wave lengths of ultraviolet light, and different sources of light will exhibit wide variations in spectral distribution and intensity.

Source of Light

Sunlight is the chief form of radiation and the most common cause for light deterioration of fibre products. The spectral distribution of sunlight at the earth's surface is about 5% in the ultraviolet region, 48% in the visible region and 55% in the infra-red region. The relative intensity and distribution of radiation from the sun, versus other sources of light, are quite dissimilar. The carbon-arc lamp emits a large proportion of ultraviolet radiation, particularly in the longer wave lengths, and produces a large amount of fibre damage. The fluorescent lamp emits less ultraviolet radiation than either the sun or the carbon-arc lamp. Nevertheless, unprotected fibres will deteriorate if stored in closer proximity to fluorescent lamps for prolonged periods of time. The incandescent lamp produces very little ultraviolet radiation and, under most conditions, is not an important source of a light of degradation.

Fibre Characteristics

The characteristics of fibre products that are most likely to influence light and weather resistance are: chemical composition and internal structure of the fibre; coloured pigments, delustrants, and other additives or impurities in the polymer; size or thickness of the fibre structure; dyes, finishes, ultraviolet absorbers, and other agents applied to the fibre product during processing or use.

Direct vs. 'Under Glass' Exposure

After twelve months of exposure, the test items exposed under glass retained more strength than duplicate items exposed to direct sunlight. This was expected since the shorter, more harmful, ultraviolet rays are filtered out of sunlight by ordinary window glass.

Spring/Summer vs. Autumn/Winter Exposures

After six months of exposure, the specimens exposed during the autumn and winter months almost always retained more strength than duplicate specimens exposed during the spring and summer months. For most fibres, this difference in the rate of deterioration was caused by the larger amount of ultraviolet light that reaches the earth's surface during the spring and summer months when the sun's path is more directly overhead.

Effect of Yarn Type

Different types of yarn from the same family of fibres may exhibit obvious dissimilarities in their resistance to sunlight and weather. These usually result from a deliberate modification of the fibre polymer or structure, made to achieve a better balance of fibre properties, or a desired yarn characteristic for a specific end use. In general terms, for direct exposure, acrylic staple retains more strength than filament nylon, which is better than polyester staple.

Effect of Fibre Lustre and Pigmentation

The light resistance of a virtually all fibres dramatically improves when black pigment is dispersed in the polymer during fibre manufacture. Conversely, the light resistance of many fibres decreases when the amount of delustrant added during fibre manufacture is increased. Thus, bright fibres are usually more durable than semi-dull fibres which, in turn, are more durable than dull fibres. The effect of delustrants is very evident with nylon fibres, but is minimal with dacron polyester fibres.

Effect of Dyes, Finishes and Other Agents

The rate of a deterioration of fibres may be affected appreciably by the presence of dyes. Some dyes adversely affect the light resistance of fibres. Others are very effective in increasing the light resistance of Nylon 6.6. Finishes, coatings, and ultraviolet absorbers which filter out the ultraviolet rays are sometimes applied to fibres to increase the light resistance. To be effective, such materials must be durable to end-use conditions, and should not have an unfavourable effect on other properties of the fibre product.

Effect of Filament Denier

The light resistance of a yarn increases with the denier of the individual filaments, probably because less radiation penetrates into the interior of the fibre. DuPont experience and tests show that this also applies to ropes where the outer layer of fibres apparently shield the inner fibres from radiation damage. For ordinary textile products, neither the size of the yarn nor the thickness of the fabric appear to have a significant effect on light resistance - possibly because none of the individual filaments is completely buried within the yarn or fabric.

Effect of Fibre Cross-Section

The cross-sectional shape of a fibre can influence the reflection, refraction, and transmission of light waves impinging on the fibre. Hence, yarns representing different cross-sectional shapes of the same fibre may exhibit a significantly different degree of light resistance. Nylon 6.6 yarns with a round cross section have a slightly better resistance to sunlight and weather than similar yarns with a trilobal cross-section.

Effects of Moisture

The stress-strain properties of most DuPont industrial yarns are not affected significantly by humidity. Nylon shows a modest decrease in tenacity with increase in humidity. When wet, however, some yarns (e.g. nomex, nylon) have significantly less strength than when dry, while others are essentially unaffected (e.g. teflon, dacron).

Effects of Temperature

The physical properties of virtually all fibres are affected by changes in temperature. Some temperature-induced defects, notably those involving changes in strength, are temporary, provided that deterioration of the fibre does not occur. Prolonged exposure to high temperatures can result in thermal degradation and permanent strength loss. Other temperature-induced effects, such as a fibre shrinkage, also can be permanent.

Resistance to Deterioration

Polyester is generally superior in resistance to degradation by acids and oxidising agents such as bleaches, while nylon is superior in resistance to alkalis.

Sunlight and Weather Resistance

It is noted that "... all organic fibres, whether natural or man-made, will degrade to various degrees from exposure to ultraviolet light. Although heavy industrial fibre products, such as rope and webbing, degrade at a slower rate than fibres in yarn form, for end-uses where strength, elongation or toughness is critical, precautions should be taken to protect fibres from prolonged exposure to sunlight, fluorescent light and other sources of ultraviolet radiation ...".

Note:

This summary is taken from **DuPont Technical Information** Bulletin X-203, 'Light and Weather Resistance of Fibers', April 1966; and Bulletin X-272, 'Properties of Dupont Industrial Filament Yarns', July 1988.

Provided by:

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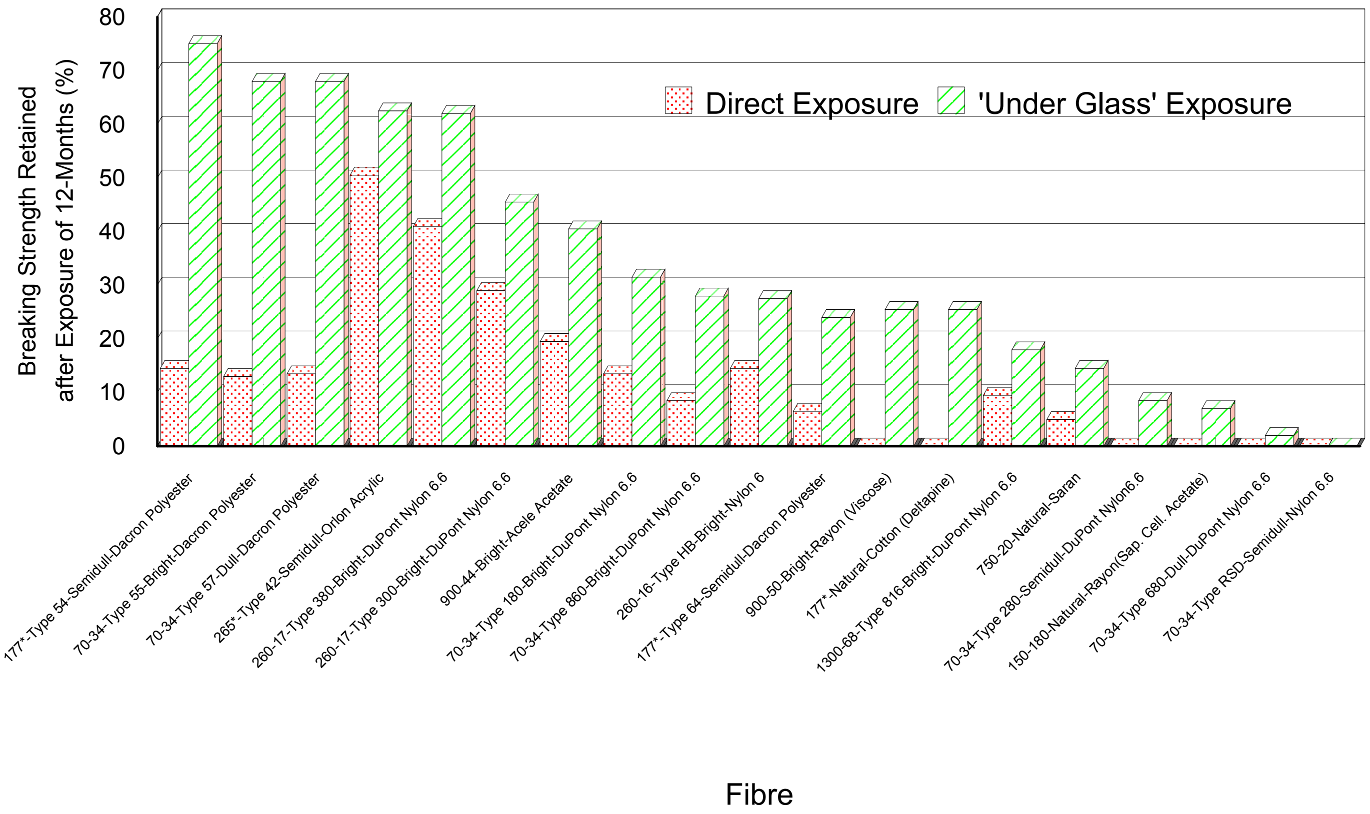
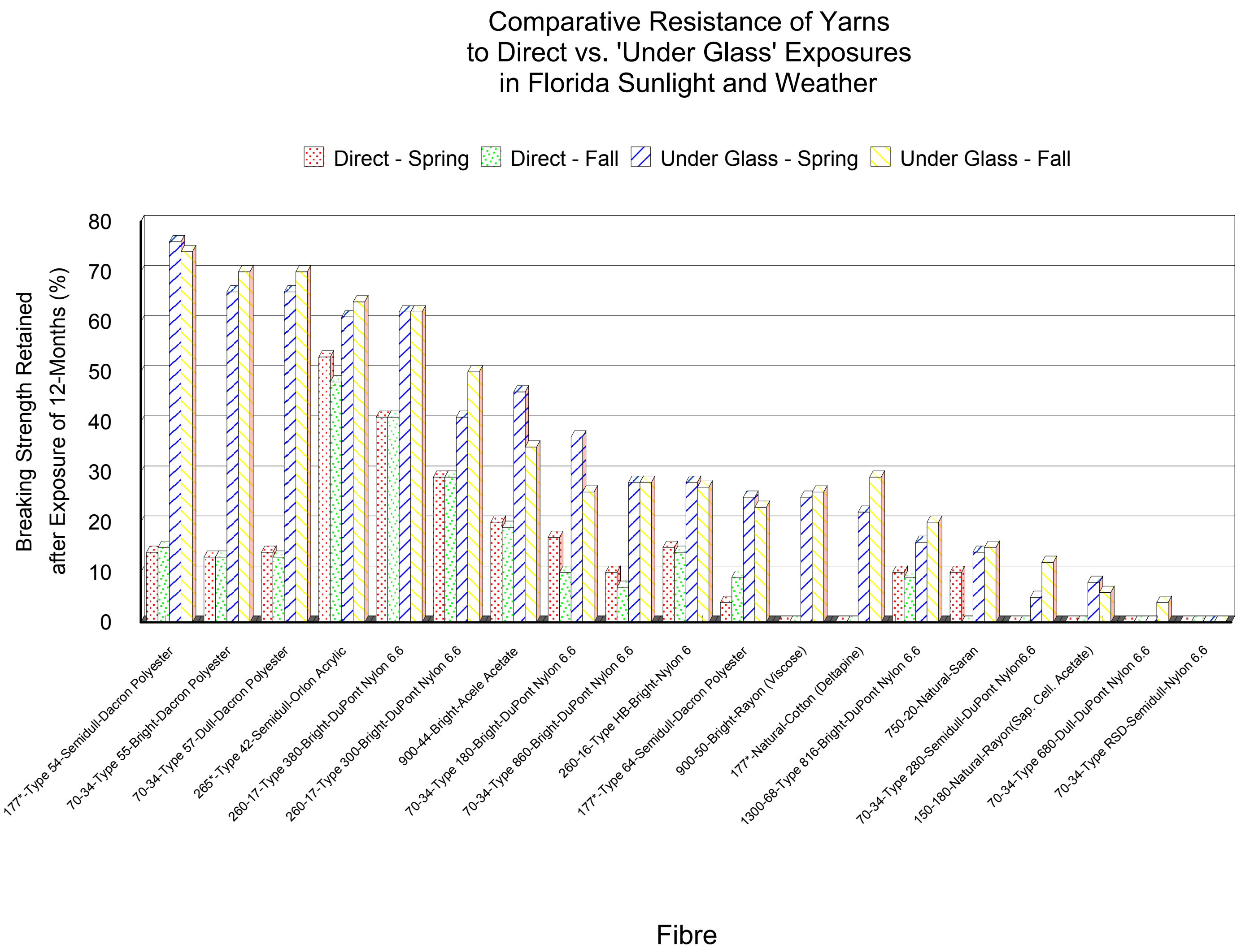
Comparative Resistance of Yarns
to Direct vs. 'Under Glass' Exposures
in Florida Sunlight and Weather




Comparative Resistance of Yarns
to Direct vs. 'Under Glass' Exposures
in Florida Sunlight and Weather
Direct - Spring
Direct - Fall
Under Glass - Spring
Under Glass - Fall
Breaking Strength Retained
after Exposure of 12-Months (%)
80
70
60
50
40
30
20
10
0
177*-Type 54-Semidull-Dacron Polyester
70-34-Type 55-Bright-Dacron Polyester
70-34-Type 57-Dull-Dacron Polyester
265*-Type 42-Semidull-Orlon Acrylic
260-17-Type 380-Bright-DuPont Nylon 6.6
260-17-Type 300-Bright-DuPont Nylon 6.6
900-44-Bright-Acele Acetate
70-34-Type 180-Bright-DuPont Nylon 6.6
70-34-Type 860-Bright-DuPont Nylon 6.6
260-16-Type HB-Bright-Nylon 6
177*-Type 64-Semidull-Dacron Polyester
900-50-Bright-Rayon (Viscose)
177*-Natural-Cotton (Deltapine)
1300-68-Type 816-Bright-DuPont Nylon 6.6
750-20-Natural-Saran
70-34-Type 280-Semidull-DuPont Nylon6.6
150-180-Natural-Rayon(Sap. Cell. Acetate)
70-34-Type 680-Dull-DuPont Nylon 6.6
70-34-Type RSD-Semidull-Nylon 6.6
Fibre

ANNEX K - SUMMARY OF PROPERTIES OF VARIOUS MATERIALS

Extracted from BS 8093: 1991 'The use of safety nets, containment nets and sheets on constructional works' (Appendix B)

Summary of the properties of various materials					
Property	***Polypropylene***[51]	***Polyethylene***		***Polyester***	***Polyamide (Nylon)***
		Low Density	***High Density***		
Minimum Yarn Strength (mN/m^2)	350	---	300	600	600
Melting Temperature (ºC)	180	100 to 115	135	250	210 to 250
Approximate Softening Point (ºC)	80	80	50	240	200 to 240
Resistance to elevated temperatures below softening point [52]	Very Good	Poor	Poor	Very Good	Very Good
Resistance to Acids	Excellent	Excellent	Excellent	Very Good	Poor
Resistance to Alkalis	Excellent	Excellent	Excellent	Fair	Very Good
Resistance to organic solvents	Fair	Very Good	Poor	Good	Good
Resistance to sunlight [53]	Good	Very Good	Very Good	Excellent	Excellent
Resistance to Abrasion	Very Good	Very Good	Very Good	Excellent	Excellent
Resistance to sustained loading	Fair	Poor	Poor	Excellent	Excellent
Flammability	Very Good	Good	Good	Excellent	Excellent

Note:

Key to Ratings:
Excellent; Very Good; Good; Fair; Poor.

[51] Polyolefins is a general classification which covers polyethylene and polypropylene.
[52] This should be read as its resistance to degrade, weaken, or creep when exposed to temperatures above ambient but below their softening points.
[53] Provided that an adequate ultraviolet inhibitor is included.

ANNEX L - AND FINALLY ... SAFETY WARNING

BS EN 795: Deadweight Anchor Devices (Class E) - 'Man anchors'

Text presented to, and agreed by, BSI Technical Committee, PH/5, at it's Meeting on 13 April 2000.

The Class E Deadweight Anchor Device has become an acceptable means of providing a safe fall arrest anchor device on flat roof surfaces, particularly where it is not practical to penetrate the roof surface.

As the industry has expanded over recent years, a diverse range of such products have been placed on the market, and their development has brought to light a number of factors that had not previously been considered. To ensure the safety of users, BSI Technical Committee PH/5 'Industrial Safety Belts and Harnesses' (on which the Health and Safety Executive are represented) has prepared the following list of points that should be considered by companies who use such equipment:

- Has your deadweight anchor been designed and tested in accordance with the PPE 'Supply' Directive (89/686/EEC, and its amending Directives 93/68/EEC, 93/95/EEC and 96/58/EEC)?

- Were the BS EN 795: 1997 [54] and BS 7883: 1997 [55] tests carried out in accordance with the latest version of BS 7883 (Amendment No. 2 - April 1999)?

  Prior to the issue of this amendment, testing was only carried out on dry roofing surface. If there is any possibility that a deadweight anchor may be used in wet conditions (i.e. if it starts to rain - or after rain, with water trapped under the anchor device - or in its path of travel), then it must have been tested for use in the relevant roof surface type - in wet conditions.

- While deadweight anchor devices have been tested for use on single ply membrane roofs, it has recently been found that the performance of *some* (and possibly all) is far less satisfactory on embossed membranes than on plain, smooth membranes. This is thought to result from the reduced contact surface area between the anchor device and the roof surface.

  Anyone who wishes to use the deadweight anchor device on an embossed membrane surface should seek advice from the anchor device manufacturer before proceeding.

- The attention of users is drawn to the fact that no standard at present specifies tests for the fall arrest systems formed in the following circumstances:

  (a) when a full body harness is connected via a retractable fall arrester to a deadweight anchor device using a connector;

  (b) when a full body harness is connected to a deadweight anchor via a energy absorbing lanyard to a deadweight anchor using connectors.

  Users who wish to connect such system to a deadweight anchor device are advised to seek confirmation from the manufacturer of the retractable fall arrestor or energy absorbing lanyard that their products are safe to use in this Way.

---

[54] *BS EN 795: 1997 'Protection Against Falls From a Height - Anchor Devices: Requirements and Testing'.*
[55] *BS 7883: 1997 'Code of Practice for Application and Use of Anchor Devices Conforming to EN 795'.*

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