Fulmer Newsletter

contract research and engineering in materials and process technology

No.47 April 1982

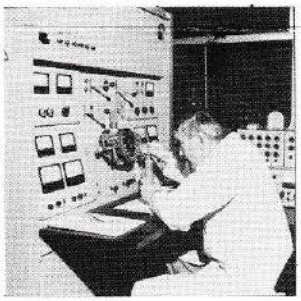
TECHNICAL SERVICES TO INDUSTRY

Product Testing

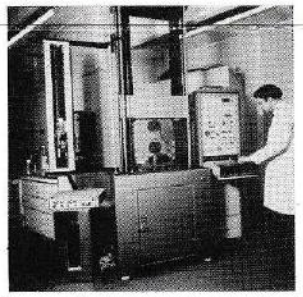
During their development and production, most manufactured goods will have been tested (i) to ensure their fitness for the purpose intended and (ii) to establish conformity with national or international specifications. If no such specification exists, a customer will often establish his own purchasing criteria. During production the manufacturer should seek to ensure that the performance and quality of the goods are maintained by carrying out quality control checks on a regular basis.

The Government, in the consultative document 'A National Strategy for Quality', recognises that the availability of suitable product standards and specifications, including testing and Quality Assurance provisions, are essential to improve the quality of British goods. However, the prime responsibility for the quality of these goods rests with industry and commerce, supported where appropriate by Government action.

One such example of Government action is the recent formation of NATLAS, the National Testing Laboratory Accreditation Scheme. As manufactured goods need to be tested to maintain standards and quality, so the laboratories who carry out the testing programmes need to be accredited to ensure that they meet certain defined criteria relating to professional competence, facilities and management structure.



Mass source spark spectrograph at Fulmer Technical Services



Howden 100kn tensile/compression testing machine with non-contacting optical extensometer at Yarsley Technical Centre

Fulmer welcomes the formation of NATLAS. Fulmer Technical Services and Yarsley Technical Centre, both of whom offer extensive services for product testing, have been approved by NATLAS because of their previous registration by the Ministry of Defence to Defence Standards 05-32. Our testing facilities are also accredited by many other National Agencies and the aim of NATLAS to reduce the multiplicity of accreditation schemes should greatly reduce the time required to administer these different schemes. For example, the Yarsley Technical Centre is accredited by:

Civil Aviation Authority Official Approval A1/4621/55

Department of Industry approval to carry out prescribed tests:

Schedule 2 to the Consumer Safety Act 1978 and

Regulation 6 of the Upholstered Furniture (Safety) Regulations of 1980

Department of Environment Supervisory Scheme for Fire Test Laboratories

Leyland Cars

Listed in the British Calibration Service Directory of Approved Laboratories

Approval No. 01-07

In this Newsletter we give examples of product testing programmes which we have undertaken for companies in a wide range of industries. Further information on our Testing Services may be obtained from:

Dr. W.E. Duckworth, Fulmer Research Institute Ltd. Stoke Poges, Slough, SL2 4QD
Telephone: Fulmer (02816) 2181 Telex: 849374

Fulmer's engineers have an international reputation for expert investigation of failed components. Despite stringent testing of components during their development and manufacture, failures do sometimes occur, often due to abusive use or service in conditions more severe than originally intended. If a failure does occur it is essential to determine the cause so that remedial action may be taken to prevent other similar components from failing. Hence practical recommendations are required.

Diesel Engine Failure

This engine was part of a generation set and considerable damage to the engine had occurred when a connecting rod became detached from the crankshaft and broke through the side of the engine block. The photograph (Fig.1) shows the damaged and distorted con-rod, fractured at the top of the big-end, with the two fixing bolts in place. At the bottom the two fixing bolts had broken, one as a result of a tensile overload, and the other in shear. The fracture face of the con-rod had been badly damaged during the failure, but it was possible using optical and electron microscopy, to identify a fatigue failure.

No inclusions or other unusual features that could have influenced the failure were observed on the bolt fractures or the con-rod fracture. It was noticed that the washers in contact with the con-rod underneath the bolt heads had been polished by continual rubbing against the face.

Hardness and tensile tests on the remaining portions of the broken bolts gave satisfactory results typical of a high tensile steel. Hardness tests on the con-rod indicated that it had been made from a 50 ton/in^{-2} steel, considered to be adequate for this application. Microscopic examinations of polished sections from the bolts and con-rod revealed satisfactory microstructures with no unusual features.

The key to this problem was considered to be the fatigue failure in the connecting rod. It was of a low stress, high cycle nature and would have required an appreciable time for the crack to be initiated and progress to the point where overload failure occurred. This rules out the possibility that the bolts failed first, followed immediately by fracture of the con-rod. A cyclic stress implies a cyclic movement and the most likely source of movement was the joint where the bolts failed, indicating

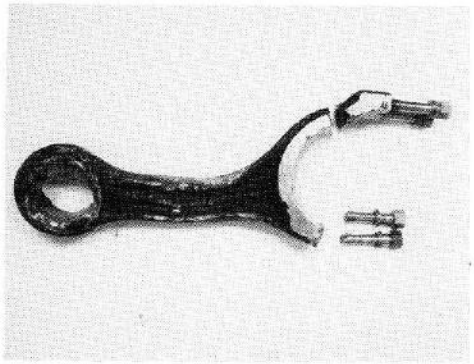


Fig. 1

that they were not adequately tight. This would account for the polishing of the washer faces.

The sequence of failure was therefore considered to have been looseness of the bolts resulting in flexure of the bearing cap. The cyclic stress was transferred by the second pair of bolts to the con-rod and initiated fatigue crack. When this crack reached a critical size, the remaining material fractured because of a tensile overload. The fracture of the con-rod resulted in the entire load being carried by the loose bolts causing them to fail.

Failed Sampling Tube

A hydraulically operated stainless steel sampling tube failed during pressure testing prior to being introduced into service. Longitudinal cracking had occurred in the interference fit end piece. Chemical analysis showed the tube and end piece to be sulphurised unstabilised 18/8 stainless steels.

Scanning electron microscopy of the fracture surfaces revealed classical quasi-cleavage morphology indicative of a chloride stress corrosion cracking mechanism. Metallographic examination of this region showed numerous branching transgranular cracks confirming stress corrosion as the mode of failure. (Fig 2 & 3).

Examination of the remaining tube length showed a dispersion of rust-like patches of corrosion. Careful manual removal of an example of this corrosion product revealed evidence of fine surface cracks. Subsequently dye penetrant crack detection was carried out on the tube which showed the cracks on the tube surface were present at all the corrosion sites. Metallographic examination of sections prepared through typical sites again showed evidence of chloride stress corrosion cracking, and energy dispersive analysis of the corrosion product confirmed the presence of chlorine.

Estimates of the residual hoop stresses present in the tubes were made by cutting a 'ring section' and monitoring the deflection when the ring was split. This indicated residual stresses in excess of 100 Nmm^{-2} which would be ample to promote stress corrosion cracking.

It was concluded that the tube had been stored in a high chloride level environment – probably marine – prior to use, during which time the residual stresses in the tube and the interference stresses on the end piece initiated a stress corrosion mechanism.

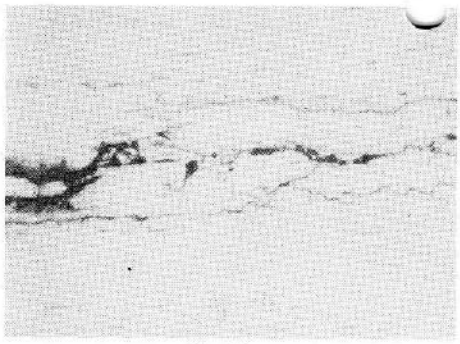


Fig. 2

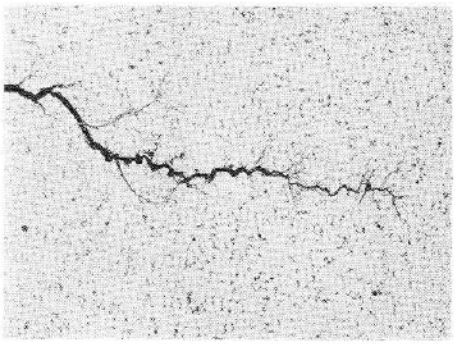


Fig. 3

Failure of an Aluminium Alloy Casting

A casting in an aluminium – 10% magnesium alloy had cracked after over 10 years' service, which included several years in the tropics. Examination of polished sections under an optical microscope revealed that the crack path was intergranular. The casting was of good quality, free from gross defects, but the microstructure contained a continuous grain boundary precipitate of beta phase (Mg_2Al_3).

It was concluded that the fracture resulted from an overload applied to a casting that had been weakened slightly by the grain boundary precipitate.

In this alloy, precipitation of the beta phase from the solid solution takes place at ambient temperatures and castings become progressively less ductile with time. Precipitation is slow at 20°C but the rate increases with increasing temperature, so that service in the tropics would result in a higher rate of precipitation, with accompanying loss of ductility, than would service in temperate regions. In addition, this particular casting had been repair welded at some time, and the heat of welding would also result in a greater amount of precipitate in parts of the heat affected zone.

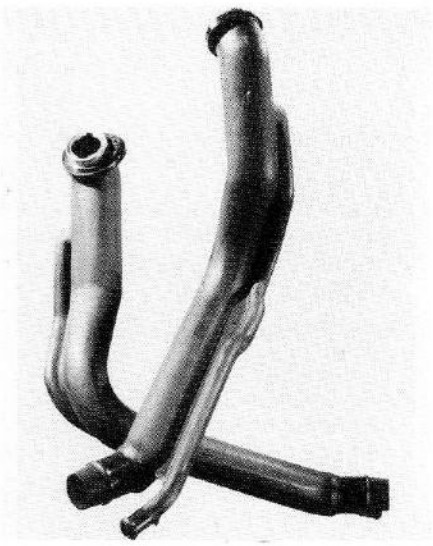
Two recommendations can be made. If castings in this alloy are welded they should be solution heat treated after welding in order to take the beta phase into solution. A similar heat treatment applied to castings after several years' service would restore the properties of the casting and so prolong the life. A sample cut from the cracked castings was solution heat treated and quenched in the laboratory in order to demonstrate the effect.

Safety in Toys

The manufacturer or importer of toys needs to be aware of a variety of statutory and voluntary standards. The principal statutory regulations cover toxicity testing of pigments or plasticisers, in particular for the presence of lead or cadmium. Most toys are designed to comply with BS 5665 which covers basic fire safety — thus, the toy must not flare if touched by a match — and certain mechanical properties, such as the force needed to remove the facial features of a soft toy. However, even if the toy is strong enough to meet the relevant British Standard it should not break in a way which produces sharp points or small parts which could be swallowed.

The testing facilities at Yarsley Technical Centre are available to carry out all relevant testing and also to assist manufacturers to produce toys which meet relevant standards.

Yarsley Research Laboratories are currently looking at the various European Regulations, Standards, Codes of Practice, etc., relating to safety in toy products, and will be publishing a report for general sale to industry which will discuss the current and future implications of such regulations on a country-by-country basis. Toy products are particularly complex in terms of health and safety since the potential hazards may be attributed either to poor design, strength, or material selection; the use of toxic paints or coatings; flammability; or the use of an infill or stuffing which could be swallowed. Yarsley Research Laboratories have been engaged as expert witness in the past in litigation cases involving injury to children through the use of inferior plastics toys.



Blow moulded filter pipes (Photo courtesy of R. B. Blow-moulders Ltd.)

Testing Automobile Components

Type-approval testing of new products may involve carrying out tests to relevant National Standards or to specifications drawn up by the manufacturer. A recent example at Yarsley Technical Centre is the testing of HDPE blow mouldings to specifications laid down by a major car manufacturer. These tests included:

- temperature cycling with 'aggressive fuel mixture' (toluene, isooctane, methanol, di-isobutylene and ethanol) followed by impact testing at −40°C;
- leakage under moderate pressure applied for eight seconds;
- shear strength of the welded-on end caps;
- chemical analysis of the polymer to confirm that degradation has not occurred during processing.

This comprehensive range of tests enabled the manufacturer to confirm the basic suitability of a design. These can then be followed up by systematic quality control testing which may repeat critical aspects of the type-approval test, or may rely on one or two easily determined properties which act as an accurate guide to the overall quality of each batch.

Standardisation of Continental Quilts — The Tog Value

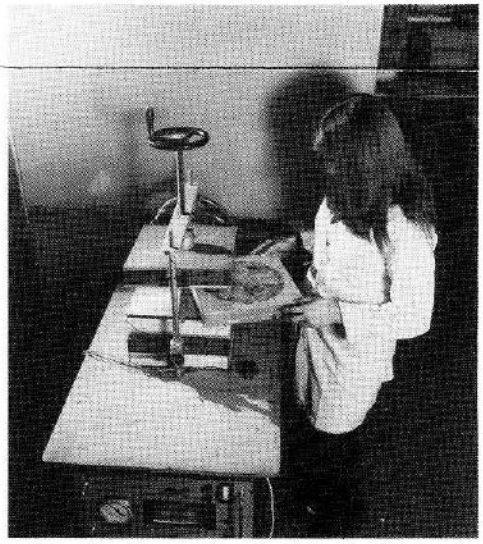
Although various natural and synthetic fillings have been used for many years in 'Continental quilts', it is only recently that the thermal conductivity properties of the various materials have been tested according to BS 874, when the Continental Quilt Manufacturers' Association sponsored a major test programme at Yarsley Technical Centre.

Various grades of feathers are used in the industry; white goose down, down and feather; feather and down; duck feathers, or poultry floss. These normally fall within a known range of 'Fill Powers', that is, a quantity determined by the volume which will be filled by a constant weight of material if no force is used to compact the sample.

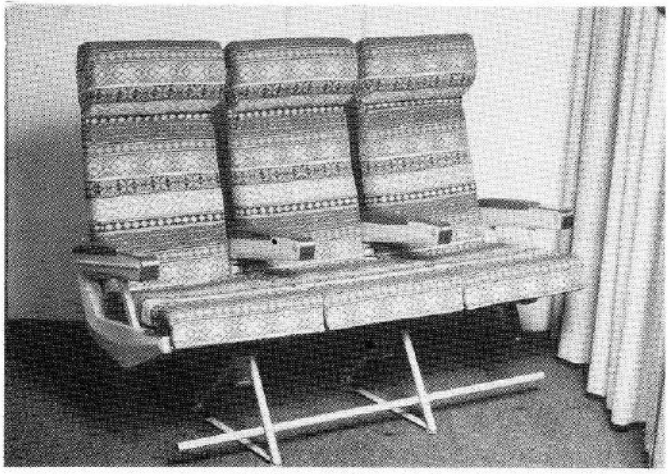
Once the thermal conductivities of all commercial filling materials have been accurately determined, it is possible to predict the 'tog value' of the finished quilt simply by checking the 'Fill Power' of each batch of filling. It is this 'tog value' which appears on the packaging of quilts as a guide for the consumer. Previously, the determination of 'tog values' required subjecting a full quilt to a conditioning and measuring routine which took several days to carry out.

Further investigations are being completed, after which it is expected that this approach will be standard in the industry.

Other test programmes carried out by the Yarsley Thermal Conductivity Department concern the properties of the various types of concrete blocks used in building — slotted, aggregate, light-weight concrete, etc, as well as tests for individual manufacturers on all varieties of insulation and other materials such as solid plastics, heat transfer fluids or metallic composites.



Sample of natural quilt filling being positioned for 'u' value determination.



(Photo courtesy of Aircraft Furnishing International)

Fitness-for-Purpose Testing

Design a better mousetrap and the proverb tells us that the world will tread a path to your door. But in every case the first question will be — 'Does it work?'

Before considering if a product meets National Standards, type-approval specifications, or quality-control limits, it must be capable of meeting its intended service requirements. The testing programme which is appropriate will depend entirely on the product and, in many instances, it will require the simulation of end-use conditions in a controlled and repeatable way.

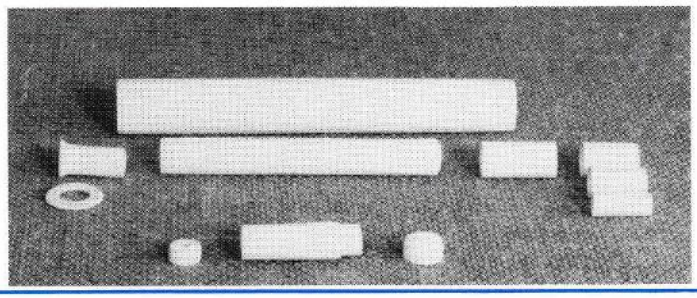
The Test Development section of Yarsley Technical Centre recently tested cushions to be used on a new type of lightweight seat for aircraft which has been designed to act as a flotation device in the event of an emergency. Testing involved immersing samples in water and establishing the buoyancy provided at half-hourly intervals — but during immersion the device had to be subjected to a squeezing action comparable to the movements of a non-swimmer.

PBN for MBE

Pyrolytic Boron Nitride cells for Molecular Beam Epitoxy are now available from Fulmer

* Cell parts with thin walls grown to size by chemical vapour deposition.
* High purity — no stray elements.
* Low vapour pressure even at high temperature — no extra molecular species in the beams.
* Low reactivity with metallic elements, particularly Al.
* No outgassing in high vacuum.
* Electrical insulators — can be used as heater element support/ thermocouple insulators.

For further details of designs and prices please contact:
Mr. C. Hayman,
Fulmer Research Laboratories.



Lightweight Tubular Structures

Details of the lightweight structures developed by Fulmer Research Laboratories for the Ministry of Defence were given in Fulmer Newsletter No.44. The technique demonstrated the considerable potential of lightweight, low cost, end fittings made from standard commercially available light alloy tubing. The fittings are manufactured by crimping the alloy tube on to a pultruded composite section with a structural paste adhesive between the components of the joint.

A film illustrating our product has been made by the Central Office of Information for inclusion in a series of science-based TV programmes, made for world-wide television distribution. We have a copy of the film in 16mm format which can be made available free of charge to borrowers.

Engineering ..... and the Younger Generation

When, as part of their sponsorship of the Design Council's Schools Design Prize, Rolls Royce designers went into the classroom, they discovered there was still ignorance about what engineers did and how they set about their work. As a result, a film entitled 'ENGINEERING IS .....' was produced by Rolls Royce in collaboration with the Design Council and Fulmer Research Institute. It sets out to dispel the 'overalls and spanner' image by showing how project work can motivate young people to think more like engineers, about the qualities and skills they need to develop, and the problems they have to solve.

(Film still courtesy of Rolls Royce Ltd)

The film shows a typical class from a comprehensive school tackling set projects using basic materials of construction (fruit cans, wood, etc) to solve the problem, and stresses the importance of working in groups to find the best solution.

Engineering ..... and the Older Generation

The importance of group working to solve a problem using basic materials and in a set time was also evident when a team from Yarsley Technical Centre took part in the BBC 'Egg Race' competition. Their winning entry can be seen on BBC2 in May.

Opportunities in Biotechnology

Yarsley Research Laboratories have been appointed as an agent on a non-exclusive basis for the sale in the UK and Europe of multiclient reports published by the T.A. Sheets Co. in Cleveland, Ohio. This company acts in a management consultancy capacity to the chemical industry and their latest report is a 350-page business study entitled 'Opportunities in Biotechnology to 1988/89'. For further information on this report and others currently available please contact:

Mr. W. Flavell, Yarsley Research Laboratories Ltd., The Street, Ashtead, Surrey, KT21 2AB (Tel: Ashtead 76391 Telex: 8951511)

SEMINARS

PROJECT PLANNING AND CONTROL FOR RESEARCH MANAGERS

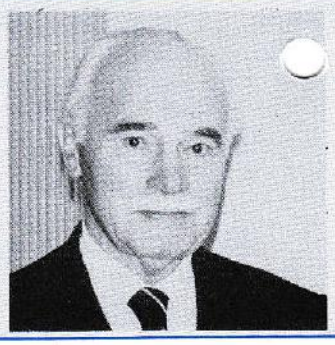
2E 500/98 3-4 May 1982

2E 500/99 24-25 May 1982

The seminar fee is £250 (+ VAT for UK participants) inclusive of accommodation and meals.

Further information from:
D.G.S. Davies, Fulmer Research Laboratories Ltd.

Dr. V. E. YARSLEY O.B.E.



The tributes and events marking the Golden Jubilee of the Yarsley Organisation last year culminated in the Award of the O.B.E. to Dr. Yarsley in the New Year's Honours List. Dr. Yarsley, who founded his company in 1931, contributed much to the plastics industry beyond his research activities. He was one of the early members of the Plastics Institute, and was particularly concerned with the education aspects of the Institute's work; he was Chairman of the PI's Education Committee for 25 years from its inception in 1935/36. He was elected President of the Institute in 1953/54. A profile of Dr. Yarsley appeared in Fulmer Newsletter No. 45.

R & D Awareness in the Process Plant Industry

A seminar was held at Fulmer Research Institute on 14th April on 'R & D Awareness in the Process Plant Industry and Improvements in British Standards'. A report will appear in the next edition of the Newsletter.

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