THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

SURVEY OF QUALITY OF AS-RECEIVED RAW MATERIALS

by

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SUMMARY

Two surveys conducted by SRAMA are reported here in which the quality of the raw materials purchased by the spring industry have been investigated.

In the first survey, random samples of raw material were requested, together with the relevant test certificate. All aspects of the specifications against which these materials were purchased were investigated, and it was found that a significant proportion of the 98 samples received were out of specification.

In the second survey, examples of wire that broke on coiling were requested. Of the 18 samples received, a high proportion were either music wire, for which the major fault was low ductility, or pre-hardened and tempered silicon chromium wire, for which the major problem was coiling faults.

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1. INTRODUCTION

Two separate surveys have been undertaken in which the quality of the raw material used by springmakers has been investigated. In the first survey, the quality of samples of raw material was assessed by carrying out routine tests to determine if the raw materials conformed to the various property clauses of the specification against which it was purchased. In the second survey, samples of wire which broke during coiling were investigated to determine the cause of the wire breakage.

The first survey was carried out because it was suspected that some raw material supplied to springmakers did not comply with the test certificate of the relevant specification. However, the extent of this problem and the range of non-compliances was not known. Every springmaking member of SRAMA was invited to submit samples, and if they did so, a free and confidential report was supplied giving the test results on the samples they submitted. This report brings together the results of these surveys, and conclusions have been drawn.

2. REQUESTS FOR SAMPLES

Every springmaking member of SRAMA was invited to submit samples for these two surveys. The letter requesting the samples is included in this report as Appendix I. Reminders about these surveys were repeatedly published in SRAMA's Newsletter.

Ninety-eight samples of spring material were received for the quality survey, and eighteen samples of wire which broke on coiling were also received. About 55% of SRAMA's springmaking members participated in one or other of these surveys but, since SRAMA was offering to undertake test work and to supply a free report giving results and conclusions, it is surprising that the response was not greater.

3. TEST METHODS

For both surveys, details of the specification against which the material was purchased were requested, together with a photocopy of the relevant test certificate wherever possible. All materials received had been purchased to British, American or German specifications, all of which were familiar to SRAMA.

The property requirements of the purchase specifications were tested for each sample, except in exceptional circumstances where SRAMA was unable to perform the test, or where the requirement was not considered likely to affect any aspect of spring manufacture or performance. For example, the 180° bend test requirements at wire sizes greater than 10 mm diameter were beyond the capacity of SRAMA test equipment, and chemical analysis was seldom checked for carbon steels since any non conformance would be very unlikely to affect any aspect of spring performance, provided all other property requirements had been met.

Typically, a sample of hard drawn carbon steel wire would be tested for tensile strength, ductility - using a wrap or torsion test, microstructure, decarburisation, surface defects, diameter, ovality and cast. If the material failed the specification requirement for any of these properties, then the test would invariably be repeated, and only if the repeat test also

showed a fail would the result be included on the SRAMA test report, as a fault or non-conformance.

For the wire breakage survey, sample fractures were requested. These were necessary in order that further information could be gained about the reason for breakage, whether or not the wire conformed to the purchase specification. Such fractures were generally examined on the scanning electron microscope, and occasionally were sectioned metallographically to check for local microstructural faults at the fracture origin. These examinations sometimes distinguished failures due to wire faults from failures due to coiling faults.

4. QUALITY SURVEY

4.1 Results

Of the 98 samples of raw material received, detailed in Appendix II, 75 were round wire, 2 flattened wire, 6 bar for hot coiling and 15 cold rolled strip. In terms of qualities, there were 11 samples of stainless steel, 18 of low alloy steel, 2 nickel alloys, one copper alloy and the remainder were carbon steels. Of the 66 samples of carbon steel, 33 were to BS 1408 and 20 to BS 5216. These samples would appear to be representative of material usage across the spring industry.

Twenty of the 98 samples were found to be out of specification in one or more aspects. The deviations observed were as follows: 11 had too high a hardness/tensile strength, 2 had low hardness, 3 were out of the size tolerance, 3 had excessive/complete decarburisation, 4 wires

exhibited excessive corkscrew set, 2 samples were very rusty, 2 had low coating thickness and one failed a bend test, as summarised in Table I.

There was no obvious correlation between any of the above faults and grade, form or size of raw material, nor any significant correlation of faults originating from particular suppliers. Ten separate suppliers were identified as having provided certified raw material with some flaw.

4.2 Discussion

Although the request for samples for the quality survey specified random samples, it was clear that, in a few instances, the samples submitted were not truly random, and faults were suspected by the springmaker. Hence it may be an exaggeration to say that 20 out of 98 samples (or 20%) of the raw material used by the spring industry is not to specification in some respect. Nonetheless, the proportion of raw material that does not conform precisely with the specification (and test certificate) against which it is purchased is of considerable concern. This concern is heightened by Product Liability and Quality Assurance considerations: springmakers cannot improve the quality of their products without the confidence and assurance that the raw material they use is exactly as they ordered.

There is some solace to the springmaker when the most frequent raw material fault is considered. High tensile strength is unlikely to affect adversely the quality of springs made, providing that all other aspects of the high tensile strength material are to specification. The other quality faults identified could all adversely affect spring quality.

This survey has clearly identified the need for springmakers to check the quality of their incoming raw material on a regular basis. Most checks that springmakers perform on raw material supplies will doubtless prove that there is no problem, but if the supplier is informed that a check has been made, then this should have the beneficial effect of reducing the chance of receiving poor material from that supplier. SRAMA strongly advocates the inclusion of random raw material quality checks into springmakers' QA procedures.

5. SURVEY OF WIRE BREAKAGE ON COILING

5.1 Results

A total of 18 samples were received, of which 7 were music wire, 5 pre-hardened and tempered silicon chromium grade, 3 hard drawn carbon steel wire, 2 pre-hardened and tempered carbon steel and one phosphor bronze.

The quality of the wire and details of the fracture appearance were examined for each of these 18 samples, in order that the most likely cause of the breakage could be determined. Results are summarised in Table II. In the case of 7 of the samples, it was concluded that the wire, either surface quality or ductility, was the major cause of the breakage on coiling. In a further 4 samples, coiling faults were deemed to be the most likely cause, leaving 7 samples for which there was insufficient evidence to determine the cause.

Of the 7 cases of wire faults, 4 occurred with music wire, of which three samples were of US origin. Two of these 4 music wires failed wrap tests, which were conducted in accordance with SAE J178 or BS 5216

specifications. It should be noted that ASTM A-228 does not specify a wrap test, which this work clearly shows is necessary for music wire specifications. The other 2 music wires would also have failed the wrap test, but the surface quality was so poor that it was not necessary to test them further.

Of the other 3 samples for which wire faults were believed to be the cause of breakage on coiling, 2 had poor surface quality, as evidenced by fine break-up of the wire surface, and the third had occasional small patches of untempered martensite at the wire surface.

This last fault was intermittent in 0.362" (9.2 mm) diameter hard drawn carbon steel wire. SRAMA was told of two other cases of relatively large sizes of wire of this grade breaking on coiling but samples were not supplied. It would have been interesting to identify the cause of breakage in these two instances, because there are considerable safety implications here.

Four cases of wire which broke due to coiling faults were identified. It is more difficult for SRAMA to be certain in these cases that coiling faults were the cause of failure, but evidence of scuffing of the wire surface and/or stretching of the wire at tight bends were seen on these failures, whereas tests on the wire revealed good surface quality and adequate ductility. Hence the balance of evidence points to coiling faults. Three of the cases occurred with pre-hardened and tempered silicon chromium quality wire. This grade is known to have inherently low ductility and special care is needed when cold coiling this material. In particular, it is important to have good alignment within the coiling machine, so that very little marking of the surface

of the wire takes place, and it is also important that tensile stresses on the wire are absent when bending it.

5.2 Discussion

The results of this survey indicate very clearly the need for particular care when coiling the highest strength spring materials available. Pre-hardened and tempered silicon chromium grade must be coiled without scuffing, and tight bends must be made with one end of the wire free to move, as prescribed in the bend test requirements of all specifications. However, if sufficient care is taken, it should be possible to coil this grade of material without problems, because the quality of the wire supplied is generally good. Music wire on the other hand is often of inferior quality when coiling problems are encountered, and a simple wrap test is likely to reveal the wire fault.

The other aspect that has been highlighted by this survey is the question of safety. There is an increasing tendency in the spring industry to cold coil pre-hardened wire of large diameter. There are good economic and quality reasons for this trend but, if the wire breaks, operators may be in physical danger. For this reason SRAMA would urge springmakers to check the quality and to audit suppliers of large section pre-hardened (hard drawn or pre-hardened and tempered) wire.

6. CONCLUSION

1. Too high a proportion of raw material supplied and certified to spring-makers is out of specification.

2. Pre-hardened and tempered silicon chromium and music wire grades are much more likely to break on coiling than other materials used by springmakers.

TABLE I QUALITY SURVEY

	BS1408, BS5216 Carbon Steels	Stainless Steel	Prehardened & Tempered	Strip	Others
UTS High	8	1	1	-	-
Size Tolerance	2	-	-	1	-
Corkscrew Set or Does Not Lie Flat	4	-	-	-	-
Rust	1	-	-	1	-
Coating Thickness	2	-	-	-	-
Wrap, Bend, Torsion Tests	-	-	-	-	-
Decarburisation	1	-	1	-	1
Hardness	-	-	-	3	-
Transverse Ductility	-	-	-	1	-
Surface Defects	-	-	-	-	1
OK	42	8	8	9	11

TABLE II SURVEY OF WIRE BREAKAGE ON COILING

	Music Wire	Pre H + T Silicon Chromium	Hard Drawn Carbon	Pre H + T Carbon	Phosphor Bronze
Poor Wire Quality	4		2	1	
Coiling Fault		3		1	
Reason Not Positively Identified	3	2	1		1

APPENDIX I

LETTER REQUESTING SAMPLES

Dear Mr

As part of the co-operative research programme for 1987/88, 2 projects are entirely dependent upon the co-operation of members. These are:-

1. Survey of Quality of As-Received Raw Materials

For which SRAMA requires 2 random samples of the raw material your company purchases. No restriction is placed upon the type of raw material, but SRAMA would like to receive sufficient material to enable full testing to ensure its conformance to the specification against which it was purchased. For instance, a company might submit:-

Raw Material From	xzy springs
Quantity Supplied	two metres of wire in 250 mm lengths
Purchase Specification	0.80 mm diameter BS 5216 ND3 or
(test certificate enclosed)	0.438" diameter ASTM A232

The purpose of this survey is to check the proportion of raw material purchased by springmakers that fails to conform to the purchase specification. Naturally, a brief report giving test results will be sent to each springmaker submitting samples for this work, and no charge will be made for this report.

We look forward to receiving samples from every springmaking member of SRAMA.

2. Survey of Wire Breakage During Coiling

In which SRAMA invites springmaking members to submit samples of wire that broke during the coiling operation. The purpose of this programme of work is to establish the extent of this problem and to identify the most common causes of wire breakage. If any member has had problems of this type in the past, but has no samples to submit at present, we would like to hear from him. Any wire that breaks on coiling, for no apparent reason during 1987, will be of interest to SRAMA in this programme of work. Sending samples for these two surveys will help SRAMA to help you.

Thank you in anticipation for your co-operation.

Yours sincerely

M P Hayes
Head of Materials

APPENDIX II

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
BS 2056 302S26 Grade II	2.34	YES	-
BS 2056 302S26 Grade II	3.048	YES	-
BS 2056 301S81	1.51	YES	-
BS 2056 316S42	3.25	YES	-
BS 2056 302S26 Grade II	1.422	NO	Tensile strength too high
BS 2056 316S42	2.95	YES	-
BS 2056 302S26 Grade II	2.337	YES	-

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
ASTM A-228	1.143	YES	-
QQW-423 302 Type ASTM A313 AMS5688	0.381	YES	-
ASTM A401	2.184	YES	-
ASTM A401	1.588	YES	-
ASTM A232	1.626	YES	-
ASTM A232	3.25	YES	-
ASTM A232	5.05	NO	Tensile strength slightly high
ASTM A401	11.10	YES	-

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
BS 1408 C3	0.711	NO	High tensile strength
BS 1408 B1 Galvanised	1.42	YES	-
BS 1408 B3	1.40	YES	-
BS 1408 B3	1.321	YES	-
BS 1408 B3	0.711	YES	-
BS 1408 C3	0.483	YES	-
BS 1408 B3 Galvanised	1.016	YES	-
BS 1408 B1 Galvanised	2.96	YES	-
BS 1408 B1 Galvanised	2.20	YES	-
BS 1408 B1 Galvanised	2.65	YES	-
BS 1408 B1 Galvanised	3.25	YES	-
BS 1408 B1	2.34	YES	-

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
BS 1408 M2	0.508	YES	-
BS 1408 M2	0.914	NO	High tensile strength or does not lie flat
BS 1408 B3	4.88	YES	-
BS 1408 B3	5.13	YES	-
BS 1408 B3 Galvanised	1.626	YES	-
BS 1408 C3 Galvanised	1.422	NO	Undersize, slightly rusty, does not lie flat
BS 1408 B2 Galvanised	0.61	YES	-
BS 1408 M1	1.93	YES	-
BS 1408 B3	2.489	YES	-
BS 1408 B2 Galvanised	1.626	YES	-
BS 1408 C3	0.914	YES	-
BS 1408 B3 Galvanised	1.422	YES	-
BS 1408 M2 Galvanised	0.813	NO	Low thickness of galvanised layer

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
BS 1408 C3	2.489	YES	-
BS 1408 C3	1.626	NO	Excessive decarburisation
BS 1408 B2 Galvanised	1.016	YES	-
BS 1408 C3	0.711	NO	Tensile strength too high
BS 5216 M5	0.607	YES	-
BS 5216 ND3	3.35	YES	-
BS 5216 ND3	1.83	YES	-
BS 5216 NS2	1.10	YES	-
BS 5216 M5	1.25	YES	-
BS 5216 HS3	1.219	YES	-
BS 5216 ND3	0.203	NO	Tensile strength too high
BS 5216 HS3	10.68	YES	-
BS 5216 HS3	3.0x2.5	YES	Note - there is no BS for flattened wire
BS 5216 HS3	1.83	YES	-

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
BS 5216 HD3 Galvanised	3.20	NO	Due to corkscrew set & tensile strength slightly high
BS 5216 HS3	2.64	YES	-
BS 5216 M4	2.159	NO	Tensile strength high
BS 5216 HD3 Galvanised	1.626	YES	-
BS 5216 Grade 2	0.711	NO	Wire diameter too large - tensile strength high, does not lie dead and not free from corkscrew set
BS 5216 Grade 2	1.219	YES	-
BS 5216 HS3	1.626	YES	-
BS 5216 HS3	0.914	YES	-
BS S201	0.914	YES	-
BS S202	1.829	YES	-
BS S205	0.711	YES	-
BS S202	3.658	YES	-
BS S201	1.626	NO	Tensile strength too high

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
BS 2803 094A65 ND	0.95	YES	-
BS 2803 G3	7.14	YES	-
BS 2803 735A50 HD	5.89	YES	-
BS 2803 685A55 HS	2.69	NO	Intermittent presence of a rim of almost complete decarb
BS 3075 NA13 Cold drawn	2.946	YES	-
QQW 470 (edition b) music wire	0.25	YES	-
Proprietary Silicon Chromium	4.47	NO	Extensive complete decarb
Lacing wire 302 Type	0.936	YES	-
AMS 5678A 17/7 PH Condition C	4.50	YES	-
BS 970: 1955 EN 48A	12.7	YES	-
SAE 5160 H Black Bar	13.5	YES	-
BS 970 250A58	20.3	YES	-

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Wire Dia/mm	Conformance	Reason
RVSS CC.3	43.0	YES	-
BS 970 250A58	18.0	YES	-
Nispan - C Hard drawn	1.626	YES	-

Specification	Width x Thickness strip/mm	Conformance	Reason
BS 5770 Pt 2	28.19 x 2.03	YES	-
BS 5770 Pt 2 Strip	15.87 x 0.508	YES	-
BS 5770 Pt 2	19.05 x 0.457	YES	-
BS 5770 Pt 3	35 x 0.5	YES	-
BS 5770 Pt 4 302S25 TR380	19.05 x 0.254	YES	-
BS 5770 Pt 4 EN 48A	15.875 x 0.381	NO	Material complies with TR330 rather than TR380

APPENDIX II (cont)

RAW MATERIALS EXAMINED IN THE QUALITY SURVEY

Specification	Width x Thickness Strip/mm	Conformance	Reason
BS 1449 1983 CS70A	25.1 x 1.63	NO	Harder than 185 Hv maximum
BS 1449 Pt 1 CS70 annealed	33 x 0.675	YES	-
BS 1449 Pt 1 CS70 annealed	46 x 1.961	YES	-
BS 1449 Pt 1 CS80 annealed	19.05 x 0.305	YES	-
BS 1449 Pt 1 CS70	17.98 x 0.457	YES	-
BS 1449 Pt 1 CSH5 4BR	17 x 0.38	NO	Width exceeds maximum allowed
BS 1449 Pt 1 CS80	31.75 x 0.508	NO	Rusty and too hard
CS70 flattened wire	7.62 x 0.965	NO	No BS for flattened wire - but surface defects are likely to affect spring performance adversely
BS 2870 CZ106H	12.7 x 0.508	NO	Low transverse ductility