

Testing of Reel Hardness with PAROtester2

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The reel hardness of wound paper or plastic rolls is an important factor of quality and success for manufacturer of such rolls as well as for companies that further process the rolled up material. The present article discusses some reasons influencing reel hardness and has its focus thereafter on state of the art test methods to retrieve the hardness of reeled up materials.

The frequency of machine interruptions and the loss of material is a major problem in the reel industry that can be minimized if evenly wound rolls are used. Unevenly wound rolls cause breaks of the wound material when further used, or during transportation. Machine stops to change the rolls or to repair defective rolls is very expensive. Reels wound too hard with a large diameter lead frequently to bursting of the outer shells, resulting in a loss of material and sometimes even in the uselessness of a whole roll. Undesired surprises of this kind are a recurring problem for converters and printers. Thus, the quality of the purchased paper rolls is of high value to them and they put corresponding requirements on the producer and supplier of paper rolls.

The reason for irregularities and high tension in the outer shells of rolls is on one hand, the technique used for reeling up, and on the other hand, the reeled material itself. The definitely produced web is transported in big machines by rolls and thereafter reeled-up under tension. This should cause an even reeling-up of the material. With increasing diameter of the reel usually also the residual stresses increase, which especially in case of big diameters causes bursting or other failures. Depending on the properties of the reeling up material (thickness, density, moisture content, ...), different pressure and tension states of the reeled-up shells have to be expected. The variation of these parameters over the broadness of the roll can be enhanced with the number of windings, causing an uneven variation in stress distribution at different roll locations and hence, limiting the properties of a whole roll. A slight variation in paper thickness over the broadness of the roll, can be multiplied with the increasing number of windings leading also to different states of tension in the roll. While unwinding the roll, such tensions cause breakage or slackening of the paper. Paper reels wound too hard or too soft and unevenly wound rolls lead to problems during the unwinding process and to damages of machines.

At an earlier stage attempts were already made to retrieve the reel hardness and its even or uneven profile over the broadness of rolls. Qualitative Testing with a wooden stick is still conducted nowadays (Fig. 1), known as “the baktender’s helper.” The tester beats the stick on the surface of the reel and listens at the same time to the produced sound. The result of such tests is only meaningful if big differences in the reel hardness are present. Obviously the test depends on the tester and his physical conditions and cannot be reported quantitatively. Thus, for companies with

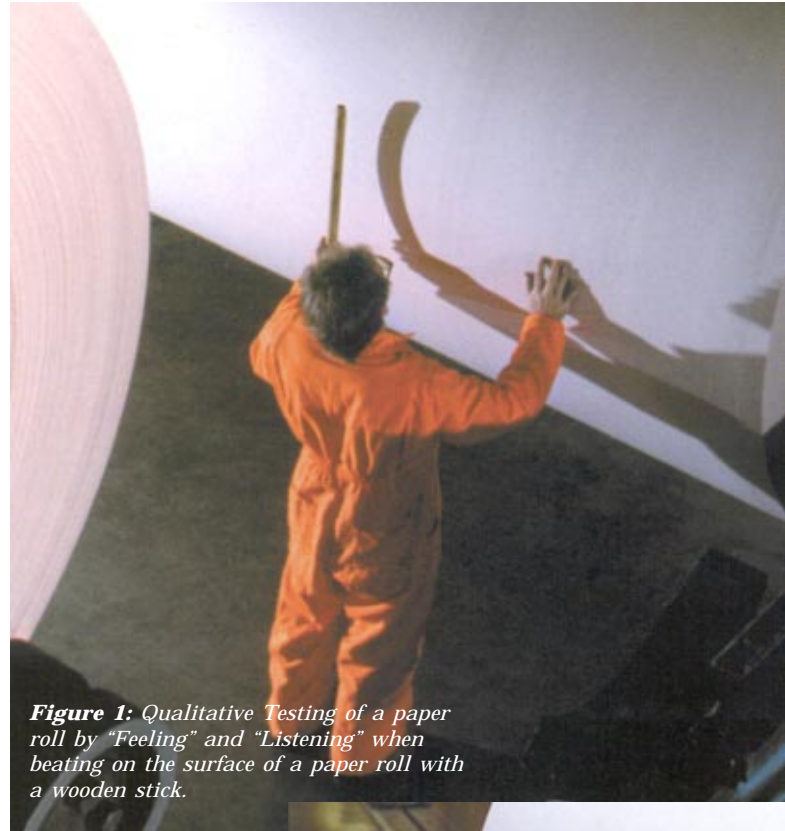


Figure 1: Qualitative Testing of a paper roll by “Feeling” and “Listening” when beating on the surface of a paper roll with a wooden stick.



Figure 2: Testing and registering mechanically the hardness profile with the concrete test hammer SCHMIDT, Typ LR.

high quality requirements the test is not satisfactory. Repeatability, accuracy and the possibility for documentation as well as the comparison of different rolls is needed.

Because of these requirements the qualitative test of reel hardness on rolls found its substitution in the early 70’s by a quantitative, user independent test with the so-called SCHMIDT hammer (Model L and LR, i.e. with and without mechanical registration possibility). This simple, portable and robust instrument was primarily designed to determine the compressive strength of concrete and building material. The instrument is pressed with the pin against the paper roll and the integrated spring is compressed (Fig. 2). After reaching a defined position, the spring is mechanically released and a hammer is propelled on the pin. Depending on the hardness of the test material, the hammer rebounds more or less. The length of the rebound is indicated on an analogue scale, which in case of testing concrete is directly related to the compressive strength of it. If measuring in

evenly distributed steps over the broadness of the roll, in a short time the profile of the reel hardness is measured. For each type of roll empirical values are obtained and a measure for the quality of the roll can be given. Now it is possible to compare rolls of the same type and also of a different type with each other and a quality standard can be written (e.g. TAPPI T-834). Rolls wound too hard or too soft or rolls with big changes in hardness are recognized before use and may be sorted out.

The Schmidt hammer is designed for the concrete and building industries. It works with an impact energy of 735 Nmm (0.735 J), and operates due to its construction, on a mechanical basis, causing frequent maintenance and calibration. A revision of the instrument after 1000-2000 impacts is required. If used in the concrete industry, a service interval after several months is necessary. Because of the solely mechanical operation and construction of the Schmidt hammer, several limitations arise if used to test paper and plastic rolls:

- The limited number of impacts before the required revision is reached practically every day, thus, a high intensity of maintenance and frequent calibration is necessary.
- The numerous possibilities for internal frictions influence the accuracy of the test results and cause a high demand on wear parts.
- The measuring range optimised for concrete testing is only poorly resolved on the analogue scale, often not sufficient for the reel industries.
- The Schmidt hammer has to be re-adjusted frequently and if not regularly calibrated more errors and bias in precision have to be expected.
- The dependence on measuring direction (gravitational effects) has to be corrected according to supplied tables.
- Model LR has integrated a mechanical writer recording the results directly on paper. Also these parts are affected by wear.

Table 1: Specifications on PAROtester2.

Impact energy	200 Nmm (0.2 J)
Impact velocity	3.9 m/s
Max. penetration depth	4 mm
Mass of impact body	26 g
Radius of calotte	25 mm
Loading force	120 N
Impact device (diameter, length, weight)	45 mm, 300 mm, 900 g
Measuring accuracy	±6 L
relative to a hardness level of 600 L	±1%

- The round pin causes sliding of the instrument during the measurement, what makes the test meaningless and can even cause damage of the instrument if it falls on a hard concrete floor. The correct way to position the Schmidt hammer depends on the person performing the test and he or she is responsible for additional inaccuracies.
- The relatively high impact energy can destroy the surface of specific rolls.

PROCEQ SA, manufacturer of the Schmidt hammer, encountered these needs by developing in close contact with producers of paper rolls in Switzerland, Japan and USA, a specially suited instrument for the paper industry, which was released to the market in the early 90s. The instrument is called PAROtester (Paper Roll Tester). The aim for the new development was to eliminate the weaknesses of the Schmidt hammer and to take advantage of modern electronics.

Based on the EQUOTIP®-principle – invented and patented by PROCEQ SA and standardized according to ASTM A 956-96 – a robust and almost maintenance free instrument could be presented. An impact body with a calotte like test tip is propelled with defined energy by spring force to the test surface. This impact body contains a magnet generating an induction signal when flying through a coil positioned close to the surface of the material to be tested. This induction signal (**A, B in Fig. 3**) is measured and it is proportional to the velocity of the impact body. The ratio of the rebound and impact velocities (v_r, v_i) gives the hardness value “L” of the PAROtester measurement; $L=1000 \cdot v_r/v_i$. Thus, an unambiguous and standardized measure for hardness is set, making the exchange of test results between reel producers and consumers possible, i.e., a PAROtester in USA gives identical hardness values as a PAROtester in Japan. If required, the correct operation of the instrument can be verified by performing a quick and easy test on a calibrated reference test block. Some technical parameters on PAROtester2, the present instrument generation on the market, are collected in **Table 1**.

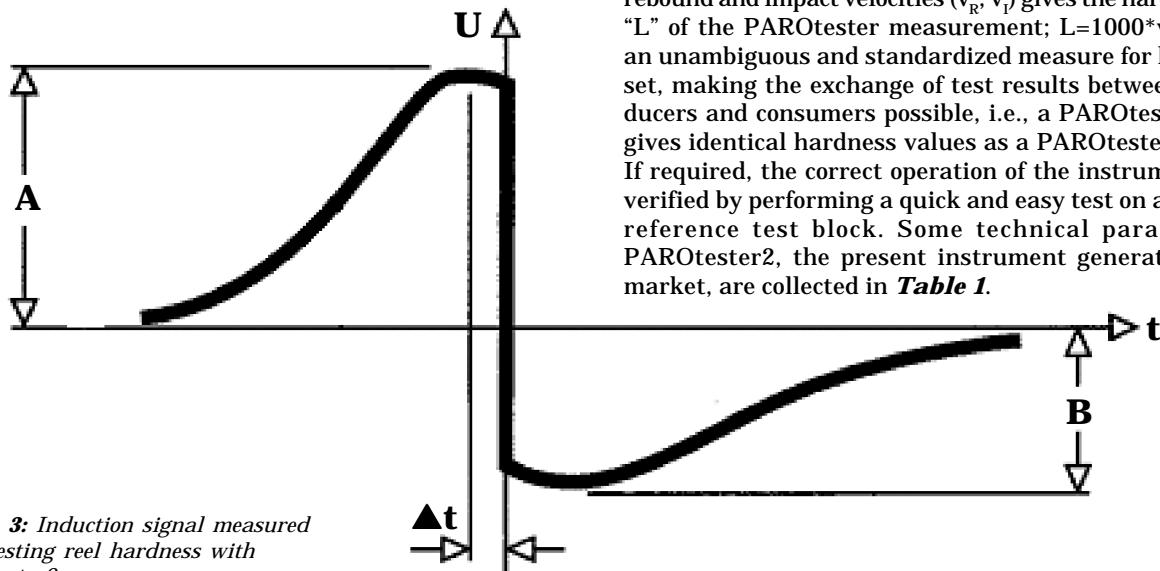


Figure 3: Induction signal measured when testing reel hardness with PAROtester2.

PAROtester2 (**Fig. 4**) is specially known for the following properties:

- Simple and safe handling of the instrument
- Automatic loading and releasing of the impact body by putting the instrument on and pressing it against the test surface
- Objective, high precision and reproducible results (instrument accuracy $\pm 1\%$)
- High resolution of the test results
- Integrated auto-test of impact device and electronics
- Large and informative LCD display
- Presetting the impact direction for electronic corrections of gravitational effects
- Flexible setting of measuring range and limits in the displayed diagram
- Display of single values and mean value with additional statistical information
- High wear resistance and reduced maintenance intensity (several 100'000 impacts)
- Simple menu guide (3 menu languages integrated)
- Automatic saving of test results (approx. 5000 single measurements) with date and roll's identification name (can be programmed individually)
- Fast recall of saved measurements
- Documentation via RS232C to printer or PC (Software package PAROLINK3)
- Conversion from hardness value "L" of the PAROtester to the hardness value "R" of the Schmidt hammer for the application on paper rolls

Thus, a reliable instrument easy to maintain is available to perform objective and quick tests of the reel hardness, the hardness profile and the hardness distribution – all with high resolution and reproducibility (**Fig. 5**). Fast and easy measuring becomes feasible owing to the specially designed mechanics, which after placing the instrument on the roll automatically loads and releases the impact body

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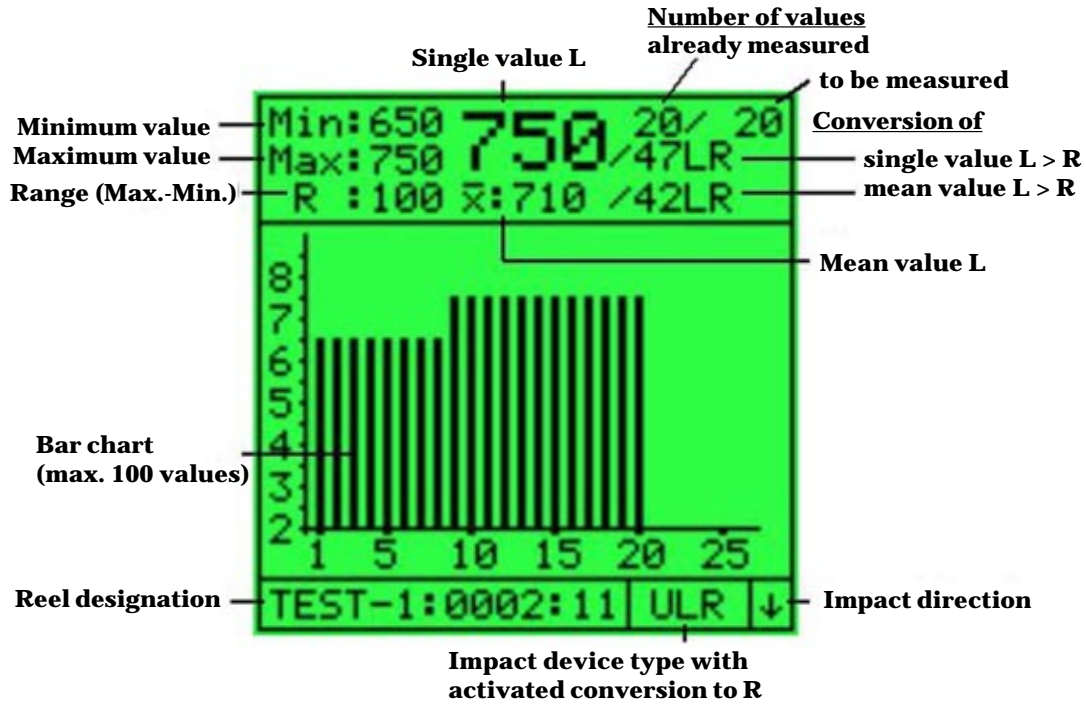
Figure 4: PAROtester2–Impact device with indicating device and optional printer.

when pressing against the surface of the roll. The user-friendly indicating device with optical display of the test results, the related statistics and the saved roll-identification name makes the immediate control of the test possible (**Fig. 6**). The saved test values can also be inspected at a



Figure 5: Testing of the reel hardness and its distribution along a paper roll with PAROtester2. The connected printer makes a direct print-out of the test results.

Figure 6: Typical display of PAROtester2 during the performance of a test.



later point in time. The memorized test series are transferred to a printer or to a PC via interface RS232C. The specially for this purpose written PC-Software PAROLINK3 fits perfectly the requirements for documentation and Quality Management in general.

As customers don't like to change the established test procedures and many of them are used to the Schmidt hammer and its limitations, their needs are respected and considered by the new PAROtester2. Now the conversion from the PAROtester "L" value to the "R" value received with the Schmidt hammer on paper rolls can simultaneously be displayed (**Fig. 6**). The conversion L > R is valid for testing on paper rolls and was established after the correlation of both values could be shown on a large number of paper rolls. Thus, the cross-check of both methods applied on paper rolls is feasible and the specifications

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written in the hardness value "R" of the Schmidt hammer can be changed step by step as the customers get used to the "L" values of the PAROtester.

The high resolution of the PAROtester opens new applications in the reel making industries as even small differences in reel hardness can be detected. The instrument, is successfully used to test foils, films and coated paper reels, too. Even packing, tapes, etiquettes and bags are tested with PAROtester and producers and users of these various products can check, optimise and hold the quality of their products. The quality of the different reels of more and more thin and special materials is a decisive success factor for producers, converters and end users of those rolls. PAROtester is the suitable instrument to find irregularities in the reels and to reliably assure the quality of rolled-up paper, foils and films.

