

Coiled Tubing Stripper Packers

Also known as stripper rubbers or stripper packer rubber inserts.

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Overview

This guide explains how Benoil Stripper Packers were developed and provides advice on best practice for their use. Benoil Stripper Packers are relied upon throughout the world by coiled tubing operators. Stripper Packers in the stuffing box are designed to enable coiled tubing to pass through whilst containing wellhead pressure above the BOPs.

They are made from highly wear-resistant material capable of withstanding high pressure, aggressive chemicals, and corrosive gases. A loss of seal integrity can lead to the escape of well fluids, with the consequent risks to health, safety, and the environment.

Benoil stripper packers were first introduced to the market in 1988. Since 2010, Benoil has supplied over 22,000 PU stripper packers and energisers to more than 80 oilfield services companies in 130 locations. The failure rate of our stripper packers (as far as Benoil is aware) is so low as to be negligible.



HTHP Stripper Packer for 2.375" Coiled Tubing

1 – Background

The supply of Stripper Packers was originally dominated by Bowen and Texas Oil Tool (TOT), now both part of NOV. A handful of other suppliers existed, particularly in the United States and Turkey. Most rubbers were polyurethane, although TOT also supplied nitrile and fluorocarbon options.

Historical causes of packer failures were not always obvious. Failures were often isolated, and replacement with a new set frequently resolved the issue, fostering a tendency to blame a "bad set of packers". As failures were easily remedied via replacement, there was a disincentive to investigate the underlying causes. In time, however, it became clear that demands on rubber components were increasing and that analysis and experimentation were needed.

Benoil entered the market in 1985. In about 1990, BP identified a significant problem in high-pressure dry gas wells. Nowsco (later BJ Services) organised trials of Stripper Packers, using external consultants to design and build a test rig, whilst Benoil supplied experimental rubbers. This produced the first generation of Benoil Stripper Packers. Benoil continued to develop its Stripper Packers, optimising their wear resistance and enabling their use up to 165°C and down to -40°C.

2 – Stripper Packer Development

Historical problems arose from three interactive sources (as well as human error):

- Mechanical Effects
- Equipment / Rubber Interface
- Chemical Formulation

2.1 – Mechanical Effects

Mechanical problems arose when the injector head and stuffing box were imperfectly aligned. Slight misalignment could be hard to detect but caused packers to wear prematurely, affecting one or both halves; virtually all wear occurred where the rubber was overstressed.

Additional problems arose when rusty tubing was run through the stuffing box packers; its abrasiveness could severely damage the rubber. Rust typically affected only the first few hundred feet of tubing from the outside of the reel. With older standard rubbers, this alone could cause failure. Rubber modification likewise did not cure the fault, although newer rubbers ameliorated it. Exxon had, however, reported tests showing that surface roughness of the coil was comparatively less important than other potential causes of failure.

Tubing ovality also contributed to mechanical problems. Although no direct effect on packer performance was established, it resembled misalignment: the rubber experienced greater compressive pressure where the tubing bulged and greater seal degradation at right angles to that. Ovality did not appear severe enough to cause rubber problems alone, but it accentuated wear.

2.2 – Equipment/Rubber Interface

It might have been assumed that energising the box to a very high pressure (e.g. >8000psi) would seal the rubbers securely around the tubing. This was often not the case: old standard rubbers simply broke up and wore away, wasting pumping capacity and injector head energy.

The underlying problem was frictional interaction between rubber and steel, both static and dynamic; static friction with older, dry-state rubbers could cause initial damage. Pressurising the box sealed the rubber halves to each other, the tubing, and the box walls. The rubber gripped the steel so that on start-up the tubing had to overcome this friction, causing distortion in the direction of movement. Anti-extrusion rings and brass bushes restrained this, but the initial movement still abraded the surface, and distortion persisted under dynamic friction, wearing the rubber into an easily recognised funnel shape. This effect was worsened by high squeezing pressures and rusty tubing, though it could be contained.

2.2.1 - Lubrication (External)

Using clean, smooth, lubricated tubing gave some improvement, though experience showed it was difficult to deliver sufficient lubrication. Pre-lubricated tubing had much of the lubricant wiped off by the rubber before reaching the seal interface. Pressure lubrication, via a tandem box, was better, but lubricated only the lower box running in, or the upper box pulling out, leaving the other rubber to wear unlubricated. It also required lubricants to withstand high temperature. But in practice the lubricant vapourised or broke down, causing gumming. Diesel causes polyurethanes to swell and severely deteriorate and was therefore unsuitable as a lubricant.

2.2.2 - Lubrication (Internal)

Benoil's preferred approach was to lubricate the rubber internally. Although the principle was clear, implementation proved problematic. Most obvious candidates worked only in quantities that were uneconomic or disruptive to elasticity. Inclusion of PTFE or graphite in the rubber caused it to break apart, rendering it unusable.

A proprietary additive selected by Benoil was proven to be highly effective. The resulting rubbers did not bind to the steel tubing, greatly reducing wear and wearing more evenly, making rubber loss more predictable. This mattered particularly in high-temperature and high-pressure wells, during fast tripping where heat generation was significant, and in deep or long-reach wells where reducing NPT was paramount.

2.3 – Chemical Effects

Polyurethane (PU) covers a wide class of materials with a broad range of properties that can be tailored to meet specific operating conditions. Some polyurethanes are hydrolysable and unsuitable for long-term use in water, acids or alkalis, but suitable in oil. Others are resistant to hydrolysis and oil, but less tough. Some are hard and rigid, while others are rubbery. Some behave like a gelled liquid, whilst others are foams, and so on. In essence, different base chemicals can be formulated and cross-reacted to achieve almost endless combinations of physical properties.

2.3.1 - Stripper Packer Development Stage 1

When Benoil first made stripper packers, polyurethane materials were selected to be not hydrolysable or likely to deteriorate in oil. Two PU systems were chosen, 75A and 90A hardness (the 3200 and 3100 series respectively). Hardness is a broad indicator of variation within a PU system. Figure 1 shows the variation of hardness with temperature, where hardness falls away slowly to a critical point and then drops rapidly once the compound starts to break down. This is a chemical breakdown of the polymer and is irreversible. Harder PU is stable to a higher temperature (about 110°C) than the softer rubber (about 90°C).

Figures shown in this document should be interpreted with care. One of the chief variations is time, which does not appear within the graph, but forms an important component in later comparisons.

Initial Material Thermal Stability

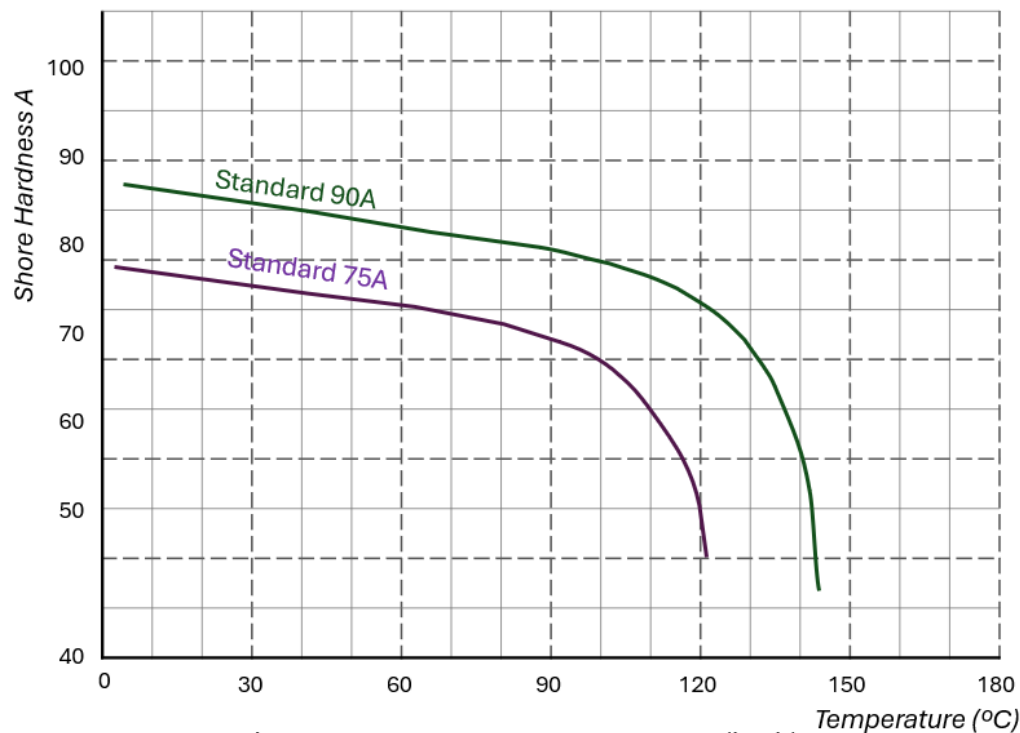


Fig 1: Effect of temperature on hardness (in air)

Improved Material Thermal Stability

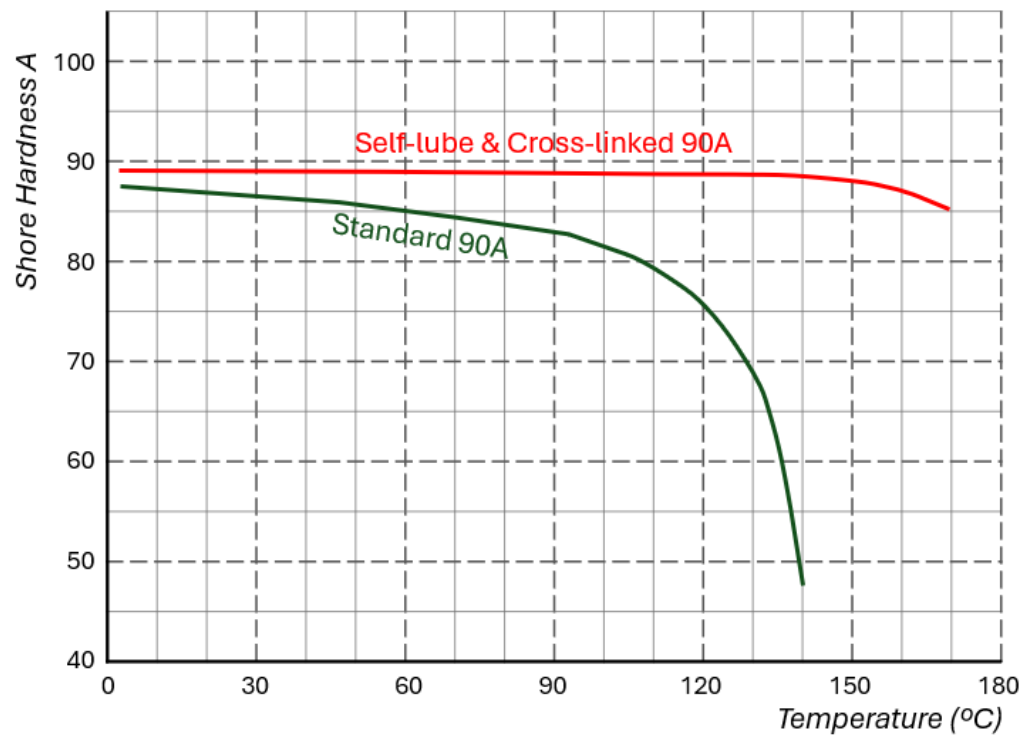


Fig 2: Effect of improved polymer system

2.3.2 - Stripper Packer Development Stage 2

With Benoil's proprietary additive incorporated, these polymers wore more smoothly with increased stability at higher temperature and pressure. Although this effect had been sought, the additive alone was not expected to achieve it, suggesting an interaction between additive and substrate beyond simple dispersion.

Pressure resistance was excellent, and on this basis the 3400 series (95A-based) was established. The 3500 series (75A-based) followed, providing a softer product that was easier to energise for low-temperature, low-pressure (LTLP) applications while retaining the smooth-wearing characteristic.

2.3.3 - Stripper Packer Development Stage 3

Further cross-linking of the polymer system raised the critical point, as anticipated, whilst only slightly increasing base hardness. Figure 2 compares the original 90A formulation with the cross-linked, additive-treated PU, showing the critical point raised to c. 165°C, a substantial improvement on the original formulation and on intermediate results at around 140°C (not shown).

This represented the maximum use level, adjusting the PU for use at high temperature and pressure, and led to the 3700 series (95A) and later the 3600 series (90A). The 3700 series was developed for BJ Services in Italy, while the 3600 series arose from demand by Schlumberger in Germany for easier energising with the same wear property. The 3600 series was later favoured by users wanting one product to cover the broadest possible operating range and came to be used by almost all coiled tubing companies.

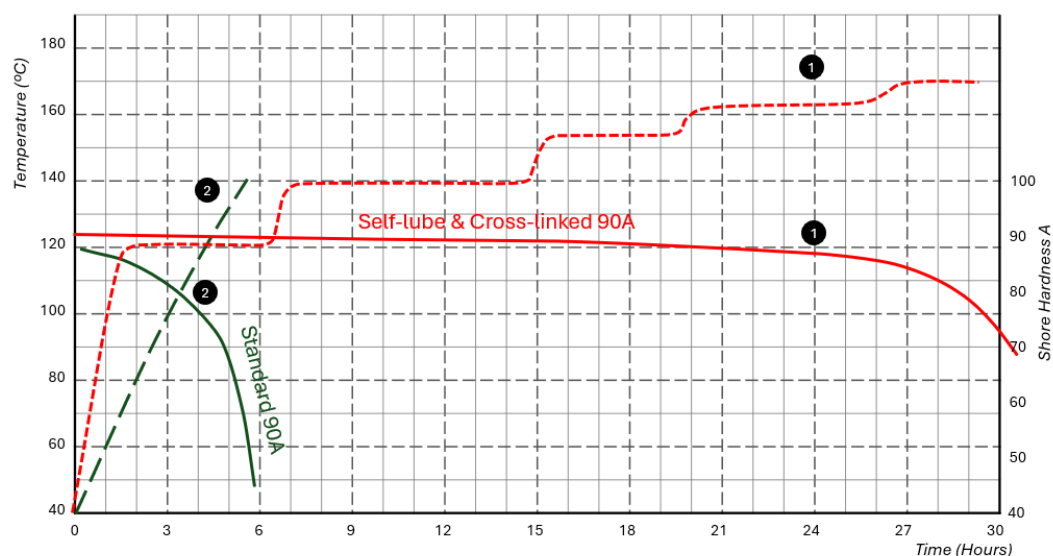


Fig 3: Effect on hardness of time at high temperature [relate 1 & 1 and 2 & 2]

Figure 3 shows the usefulness of the 3600 series (90A), and by implication the other series, plotting time rather than temperature. It presents two linked trials, where lines (1-1) and (2-2) are read together. The air-circulating oven equilibrated readily, as shown by steps in dashed line (1) when the control was adjusted. Hardness remained almost unchanged until about 155°C, with slight loss at 160°C, and significant fall-off in conditions of about 170°C after several hours.

These samples, however, were exposed to air, unlike conditions in a stuffing box. Hardness was measured at the surface, which showed browning and fumes indicating oxidation and softening. However, the bulk, once cooled and cut, proved largely unaffected; usage limits were nonetheless set conservatively. Compared with Figure 2, the original standard material showed a slower initial rise but near-immediate deterioration. A cross-linked form of the 3500 series was later developed and introduced as the 3800 series. This offered better wear, replacing the 3500s, and a very low-temperature variant suitable to -50°C. These rubbers gave good service in Norway's cold conditions and were used extensively in other geographies.

2.4 – Interlocking Halves

Alternatives to flat sealing faces, promoted by other suppliers as giving a more positive seal, were evaluated, including wavy and toothed interlocks. Tests showed no actual sealing benefit over an equivalent flat-face seal. In fact, wear in an interlocking system, once started, could be worse near the interlocking surface. Thus, such variations were not included in the Benoil Stripper Packer design.

3 – Identification & Storage

Each unit is labelled and marked with Benoil's part number and a batch date. Colours are consistent for each hardness: red denotes 95A, orange 90A, and yellow 80A.

Stripper Packers are listed in the Benoil catalogue by serial number, ID (Coiled Tubing diameter), OD, and length. The choice of OD and length depends on the stuffing box used. Benoil Stripper Packers are resistant to moisture, heat, and light, even in hot, moist conditions, and can be stored for up to 3 years.



4 – Stripper Packer Selection

The new Benoil stripper packers demonstrated longer service life than incumbent alternatives across the same temperature range and at higher temperatures, with wear occurring smoothly and predictably. This was particularly beneficial as the new rubbers were expected to outlast most normal operational runs, only needing to be changed between runs. Correct selection reduced change-out time through longer rubber life. Customers reported service lives two to three times longer than competing products, with associated reductions in NPT from fewer change-outs.

4.1 – Ambient Conditions

The ideal choice depended on well temperature and pressure but could also reflect ambient conditions, for a given well, for example, a harder or softer rubber might be chosen depending on whether it was Canadian summer or winter. The softer 3800 series proved to be the European workhorse, whereas the 3600 series was more popular in hotter climates like Venezuela, Gabon, Saudi Arabia, and Singapore, unless high pressure and temperature favoured the 3700 series.

4.2 – Range Overview

The 3700 series was created for HTHP applications. The softer 3800 series was designed for LTMP applications, with the intermediate 3600 series for MTMP completing the active range.

These rubbers offered much improved tolerance at low (-50°C/-60°F) and high (160°C/320°F) temperatures, avoided embrittlement or catastrophic breakdown at the upper limit, and showed no explosive decompression damage at high pressures, whilst resisting sour gas, carbon dioxide, cement, oilwell acids, and gas-hydrate-well methanol, gaining wide acceptance.

Not all options were equally recommendable. A Bowen 4.625-inch box could take a 4.625-inch OD x 3.00-inch ID energiser with 3.00-inch OD rubbers but was better served by Benoil's 4.625-inch OD all-in-one rubbers, reducing leak paths, a design Bowen later adopted (3679 series onward). Likewise, a Hydrarig 5.50-inch ID box could take the energiser plus 4-inch OD inserts, or all-in-one 5.50-inch OD sets for larger CT sizes; all-in-one types were strongly recommended.

4.3 – 36xx Series

90A rubber with cross-linking and self-lubrication; maximum operating temperature 160°C.

Capable of operating at temperatures from 20°C/68°F to 155°C/310°F and pressures from 1000psi to 5000psi. Recommended for use at temperatures from 40°C/100°F to 150°C/300°F and pressures from 2000psi to 5000psi. As a wearing part, they require frequent checking and should always be replaced between runs.

4.4 – 37xx Series

95A rubber with cross-linking and self-lubrication; maximum operating temperature 165°C. A harder polymer that is more resistant to wear and temperature than the 3600 series. These stripper packers require more work to energise leading some operators to choose the 3600 series, trading slightly faster wear for ease of energising.

Capable of operating at temperatures from 100°C/212°F to 165°C/330°F and pressures from 3500psi to 12,000psi. Recommended for use at operating temperatures from 150°C/300°F to 160°C/320°F and pressures from 4500psi to 12,000psi. Essential for temperatures above 150°C/300°F and pressures above 8000psi.

The 12,000psi limit reflected testing to 11,500psi with little wear, though extending this limit remains untested. Field experience in extreme wells in the UK, Norwegian North Sea, Alberta, Venezuela, Germany, Italy, Algeria, Saudi Arabia, Kazakhstan, Indonesia, and Australia produced no adverse reports.

Wear occurs at extremes above 10,000psi and 160°C/320°F but remains uniform and safe under even loading, with no brittle fracture or explosive decompression. As a wearing part, they require frequent checking and should always be changed between runs.

4.5 – 38xx Series

80A rubber with cross-linking and self-lubrication; maximum operating temperature 150°C. Intended for low-pressure, low-temperature applications requiring easy energising

Suitable for operating temperatures from -50°C/-60°F to 150°C/300°F and operating pressures from 1000psi to 4500psi.

Recommended for use at operating temperatures from -10°C/14°F to 140°C/285°F and pressures from 1000psi to 4500psi. As a wearing part, they require frequent checking and should always be changed between runs.

5 – Contact Details

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