

**SOLUTION MINING RESEARCH INSTITUTE**

679 Plank Road  
Clifton Park, NY 12065, USA

Telephone: +1 518-579-6587  
[www.solutionmining.org](http://www.solutionmining.org)

Research  
Report 2021-2



**SMRI Research Report RR2021-2:  
“Development of a Suitable Method, Monitoring and  
Advanced Warning System to Determine and  
Measure Axial Loads in Casings”**

Konrad Pfeifer, UGS GmbH, Mittenwalde, Germany

Dennis Maut, UGS GmbH, Mittenwalde, Germany

NWKG – Nord-West Kavernengesellschaft mbH

IfG – Institut für Gebirgsmechanik GmbH

**29.03.2021**

# 1 Executive Summary

The first phase of the project (developing of a new measuring system for detecting local axial load-changes in already installed last cemented casings) has already started end of 2019. This measuring system is intended to detect local strains, which allow conclusions to be drawn about still unknown geomechanical processes. The new measuring system should deliver a reliable comparison to existing geomechanical models for the respective well. The following processing points are the content of the first phase of the project:

## 1. Research work for existing measuring systems for axial load monitoring

At present, there are no measuring systems on the market that can be used to measure local load or length changes in existing boreholes. With available systems, either only total loads or total expansions of a string can be recorded or an application of the suitable measuring systems is only possible with a new installation of a pipe run.

## 2. Research work for alternative physical measuring methods

The evaluation of different physical measuring methods showed that high measurement accuracies can be achieved by appropriate technologies, which are available. The most important task, which remains challenging is the continuous power supply for the subsurface used measuring device.

## 3. Selection of a suitable measuring method for the intended development

After evaluating the advantages as well as the disadvantages of various physical measuring principles, the measurement of length changes was selected. Both, with fibre optic technology (FOC) and Fibre Bragg Gratings (FBG) in combination with an underground measuring device would be developed by UGS (figure 0).

With this method, high measurement accuracies would be achieved, long distances between sensors would be loss-free bridged and measurement tasks in explosion-critical areas would be realised.

Compared to other methods, fibre optic technology does not work with a voltage or power supply. Instead, light waves (spectrum) are used as the transmission medium. Those waves which are directed into a glass fibre by a laser diode. Certain wavelengths of the total spectrum are reflected at specially configured reflection points in the glass fibre, the Fibre Bragg Gratings. If the FBGs change their "inner" distance due to stretching, the reflected wavelength of the light consequently changes. This difference in wavelength is the evaluable measure of strain. Several sensor points (FBG) can be provided on a fibre optic cable in series connections, each of which is tuned to a specific wavelength of the induced total light spectrum.

The measuring point or the measuring device is the tool which is set in the borehole for recording strains of the last cemented casing. It is anchored in the setting depth with a slip system and can also be released again if necessary. Local strains occurring during the existing last cemented casing are real-time transferred via the anchorage to the sensor area of the measuring device. Therefore the strain is measured indirectly. The length of the measuring device or the distance between the two anchoring points can be individually adapted to the geological and technical boundary conditions of the borehole and is not limited to e.g. single casing length (handling with a work over rig). Realisable measuring lengths are between 3 - 100 m.

In general, it is also possible to install several measuring devices with different measuring length. However, this requires a practicable solution for handling the cables which are left in the borehole. The danger of damaging the cables should be excluded.

In the case of new casing installation it is possible to apply the FOC or FBG- technology on the outer surface of the new casing string. The operation with a additional measuring device which is anchored inside is not necessary. The well is freely passable without restrictions.

The installation of the measuring device is nearly independent from of the type of the well and the stored media. Depending on the chemical properties of the stored media, the materials used for certain components may have to be adapted. With the background of the remaining fiber optic cable in the borehole, the use of the measuring device in a horizontal borehole poses a special challenge to the protection of the cable, should additional casing strings be installed.

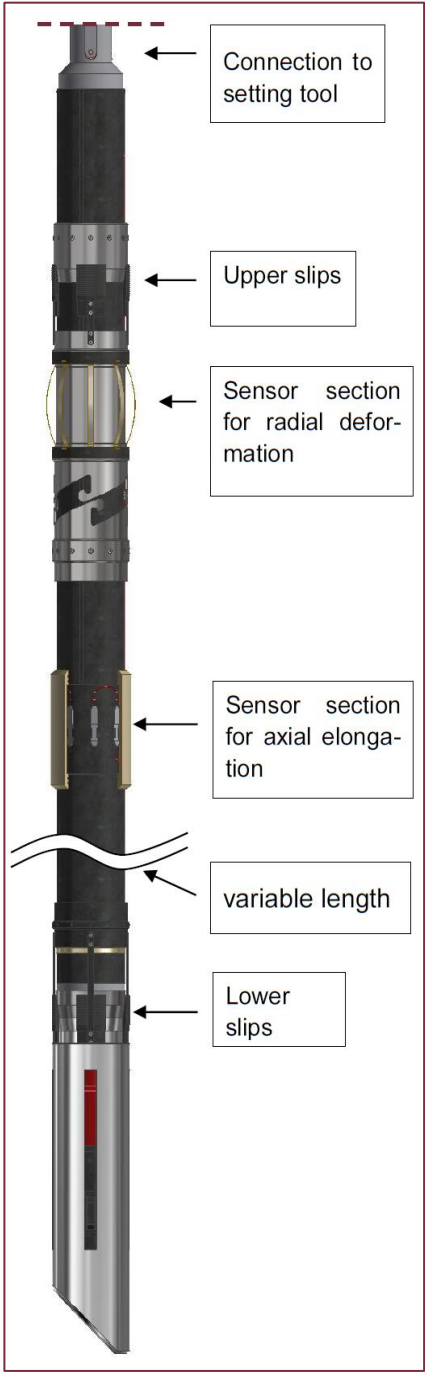
The geometric design of the sensor area leads to an amplification (translation) of the strain of the last cemented casing. Even the smallest deformations can be detected. Furthermore, radial deformations can also be detected. For this purpose, a kind of spring centriliser would detect the radial deformations and transfer them to the corresponding sensor points.

The measuring device can only measure strains that occur in the future. A statement about the initial status of the monitored casing could be done by a combination of documented facts (e.g. landing load of the string) and detected strains. A statement on the initial condition could only be made via a combination of documented facts and a comparison of measured values, with the help of which the original condition can be concluded.

The setting operation procedure and the equipment required is carried out with standardised equipment from drilling rigs. The use of the well with the installed measuring device is associated with restrictions in freely passable diameter. A reduction of the free diameter of approx. 3 inches should be taken into account. The installation of a brine completion is generally not excluded. The diameters of the leaching strings to be used depend on the design of the borehole and must be checked in detail. For the installation of a completion, the existing fiber optic cable in the borehole must be taken into account. Damage to the cable will lead to a failure of the measuring system.

An installation of this measuring system which are integrated in new installed protection casings of oil-storage wells is generally possible, but goes along with a high installation effort. Load changes occurring as a result of operation processes can influence the strain values and have to be evaluate accurate. These sytems would be installed permanently.

The fibre optic technology in combination with a measuring device offers suitable conditions in terms of achieving higher measuring accuracy and data transmission quality. The application of these FBG systems is state of the art in many areas.



**Figure 1: Basic Design Measuring device**

Taking all aforementioned facts as well as progress into consideration, the development of the obtained results and thus the technology for it is very promising. The Research hasn't shown any major restriction to continue this project for the phase 2. All obtained results advocate the technical feasibility of the intended measuring system.

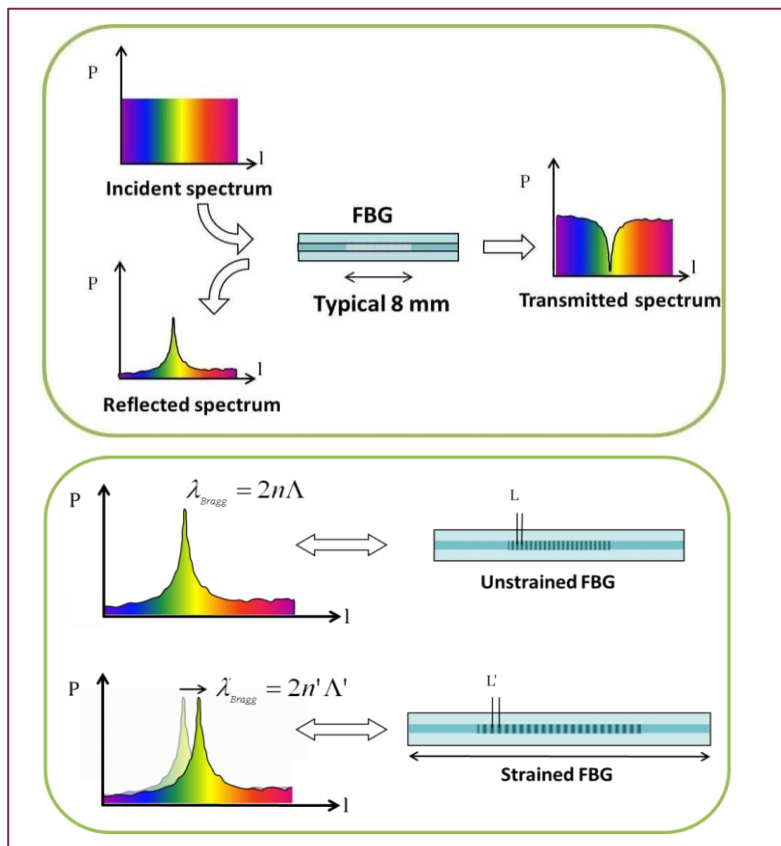


Figure 2: Operation principle FBG