SPE-221691-MS

Subsurface Safety Valve Control Line Leak Resolution Using a Pressure Activated Sealant Technology

Tryphosa Robinson, Ishomo Lucky, Ugwa Iheanyi, and Igwebike Chinedu, Mobil Producing Nigeria Unltd; Mcallister Kenny, Seal-Tite International

 DOI 10.2118/221691-MS

This paper was prepared for presentation at the SPE Nigeria Annual International Conference and Exhibition held in Lagos, Nigeria 5 - 7 August 2024.

Abstract

The integrity of critical barriers deteriorates over the life of a well. To support continuous oil and gas production, identified integrity issue needs to be properly managed and addressed.

Most integrity issues are associated with leaks around downhole completion equipment where the tubing retrievable surface controlled sub-surface safety valve (TR-SCSSV) is a critical component. The TR-SCSSV function is achieved by applying hydraulic fluid pressure through a control line (CL) to open it, or bleeding same fluid to close the valve. From the foregoing, the potential for leaks exists around CL termination or connection points, tubing hanger body and/or neck seals and SCSSV hydraulic system seals. When this occurs, the SCSSV integrity is compromised resulting in failure to open the SCSSV flapper. Such SCSSV failure is usually restored with the conventional method of a rig workover to pull and replace tubing with a new SCSSV at a considerable cost.

This paper discusses an in-situ, safe and cost-effective solution, leveraging the pressure-activated sealant technology workflow that was developed and successfully applied to candidate wells with SCSSV CL leaks. It outlines the capabilities of the Seal-Tite technology and the cost-saving production restorations achieved during a campaign in some Mobil Producing Nigeria (MPN) field locations. The overall objective was to diagnose and seal CL leaks to restore integrity, without clogging the hydraulic system or flow path to the safety valve.

Introduction

A major issue with aging wells is the development of leaks across various components of the downhole system, in this case, control lines (CL) of the surface controlled sub-surface safety valve (TR-SCSSV) designed to transmit hydraulically pressured fluid from surface to the downhole valve. The SCSSV depends on this pressure to function as designed, a set hydraulic pressure transmitted through the CL to the SCSSV flapper is required to keep the valve open during operations, any leak detected in this closed system, will automatically cause the flapper to close preventing further production from the well. With smaller leaks, the surface hydraulic pump will keep delivering hydraulic oil to the system to maintain that set pressure. These leaks can result in abnormal pressures detection along the wellbore and control systems which in effect, result in releases of control fluids, oil, gas, or other fluids posing issues of safety, environmental protection, and further cost implication.

Analyzing and fixing such CL leaks is further complicated by lack of access to downhole equipment, the unique installation of different systems and cost with delivering a fit for purpose repair solution. The conventional method of mobilizing a workover rig, pulling, and replacing the leaking piece of equipment is cost and time – demanding, and could also pose potential risks to personnel and environment. As an alternative to a massive rig or barge workover, the method deployed and described in this paper involves a safe, time-saving, and cost-effective solution designed to seal certain leaks from surface without the need of mobilizing expensive and risky intervention operations.

Conventional Repair Methods

With the deployment of conventional methods for SCSSV control line repairs, the job scope becomes further convoluted, time consuming and expensive. The direct cost of such repair operation can be in millions of dollars (considering the barge / rig cost), including risk associated with execution. Other challenges or impacts associated with the traditional method are not limited to:

- Extended duration of unscheduled volume loss due to considerable engineering and scheduling preparations prior to execution
- Availability of a rig or barge and associated service company personnel at the time of need
- The risk posed from disassembly and reassembly of equipment during the operation

These are some of the major issues addressed by the less complicated platform-based pressure activated sealant deployment approach discussed in this paper for low-moderate CL leaks.

Pressure Activated Sealant – The Concept

The pressure activated sealant consists of a super-saturated mixture of short-chain polymers, monomers, and polymerizing chemicals in a carrier fluid. The formula is regulated with additional components based on temperature, pressure, system fluids and leak rate. The sealant responds to a differential pressure detection through a leak site which causes it to polymerize into a flexible semi-solid seal only at the site of leak. It remains fluid during transportation and while pumped into CL, until it spots a leak site which causes the chemicals to polymerize. As the reaction proceeds, the polymerized sealant flattens out on the edges of the leak site and simultaneously links across the leak site to seal the leak. The remaining sealant remains fluid and poses no threat to clogging the hydraulic systems of the well.

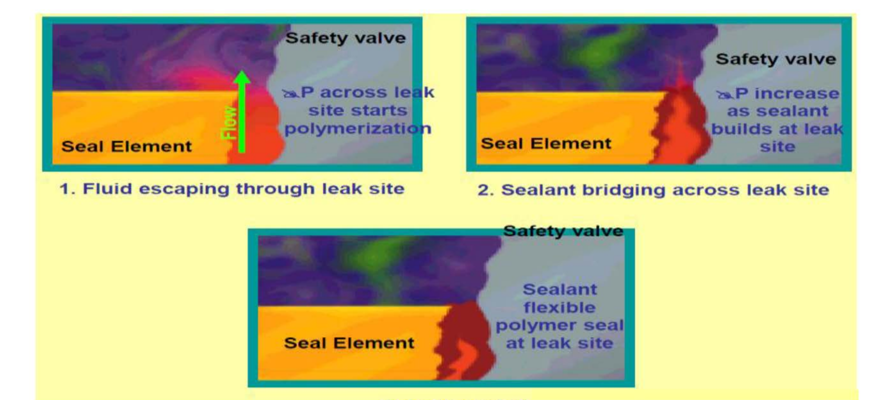

Figure 1—Pictorial demonstration of sealing mechanism across leak path

Figure 2—Polymerized sealants

Pressure Activated Sealant - Limitations

A major limitation in deploying the pressure activated sealant is its inability to bridge across a large leak. The leak geometry is vital to ensuring the success of sealing. To be effective, the leak must have a high ratio of adjacent surface area to the leak area and sealant must be implemented while the leak is not too severe. To this end, it becomes pertinent to ensure proper engineering diagnostics and leak rate checks are completed before a successful CL sealant operation.

This paper presents a sealant treatment workflow employed by MPN to aid the proper selection and definition of wells with SCSSV CL issues that can be addressed using the pressure activated sealant treatment.

Problem Statement

Wellhead maintenance programs ensure the effectiveness of a tree valve barrier health over the producing and idle lifecycle of a well. During such maintenance programs and regular operations surveillance checks, certain wells that displayed signs of a downhole CL leak like sudden increase in hydraulic returns with gas or crude, continuous stroking of hydraulic panels, frequent top-ups of hydraulic, and CL inability to sustain required pressure, were identified and isolated for troubleshooting.

In matured assets with considerable high well counts, it becomes pertinent to proactively develop a cost-effective platform-based treatment control line sealant workflow for timely execution and restoration of well integrity and volumes to aid business continuity and plan.

Methodology

A treatment workflow was developed to aid proper identification and diagnostics of issue prior to deploying the sealant solution. There are four critical components to ensure the success of a pressure activated sealant job and they are:

- Accurate diagnostics
- A proper engineered procedure
- Full implementation of the procedure
- Ensuring proper post – operational training and procedure implementation

The workflow factors in the above mentioned and limitations with sealant solution, all in an aim to ensure a proper and engineering guided decision is completed before mobilization for a job.

The workflow can be divided into two major parts:

1. Troubleshooting phase
2. Engineering assessment phase

Troubleshooting phase

Once a leak has been detected in the SCSSV hydraulic control line closed system, a detailed engineering work aid is implemented to determine the point of leak which could be around the tubing hanger neck or body seals (close to surface), connection along the line or close to the SCSSV flapper (deeper depth) and leak severity. Results obtained from the diagnostics and other tree information gathered like the CL type (continuous or non-continuous) will inform if communication paths are with tubing (sealant solution), tubing hanger void or production annulus (other solutions). If determined that leak is not at surface (around hydraulic panel) and leak is one requiring sealant deployment, the well is included in the inventory and planned for restoration.

Engineering Assessment phase

On confirmation of the leak type, depth, and severity, a detailed troubleshooting data sheet is documented and shared with the sealant providers to ascertain feasibility of repair using the pressure activated sealant technology. During this phase, a thorough analysis is carried out using different well parameters and troubleshooting results reported in the data sheet.

This information provides the sealant company with a clear and transparent understanding as to whether the different sealant grades available will be effective in sealing the leak. If a well is determined not feasible, it is placed in a higher cost demanding category and analyzed for further solution, which could span from the installation of a wireline retrievable SCSSV (WR-SCSSV) to a tubing pull solution by means of a workover barge or rig.

Over the years, based on several technical evaluations, a leak rate baseline to deploy this pressure activated sealant solution has been determined to be < 250ml/hr, and this has formed a basis for CL leaks resolution using pressure activated sealant solutions in MPN fields.

Once the inventory of wells provided have been confirmed feasible, a detailed procedure is documented (each well has its peculiarity) for execution and plans are set in place to mobilize a company representative for the job to resolve the issues and restore well integrity and volume loss with the wells shut in.

The workflow below summarizes the different steps deployed in our JV fields to ensure proper analysis are carried out to ascertain solution feasibility, all the way to training provided to the field operations team to ensure continuity of well operation post execution.

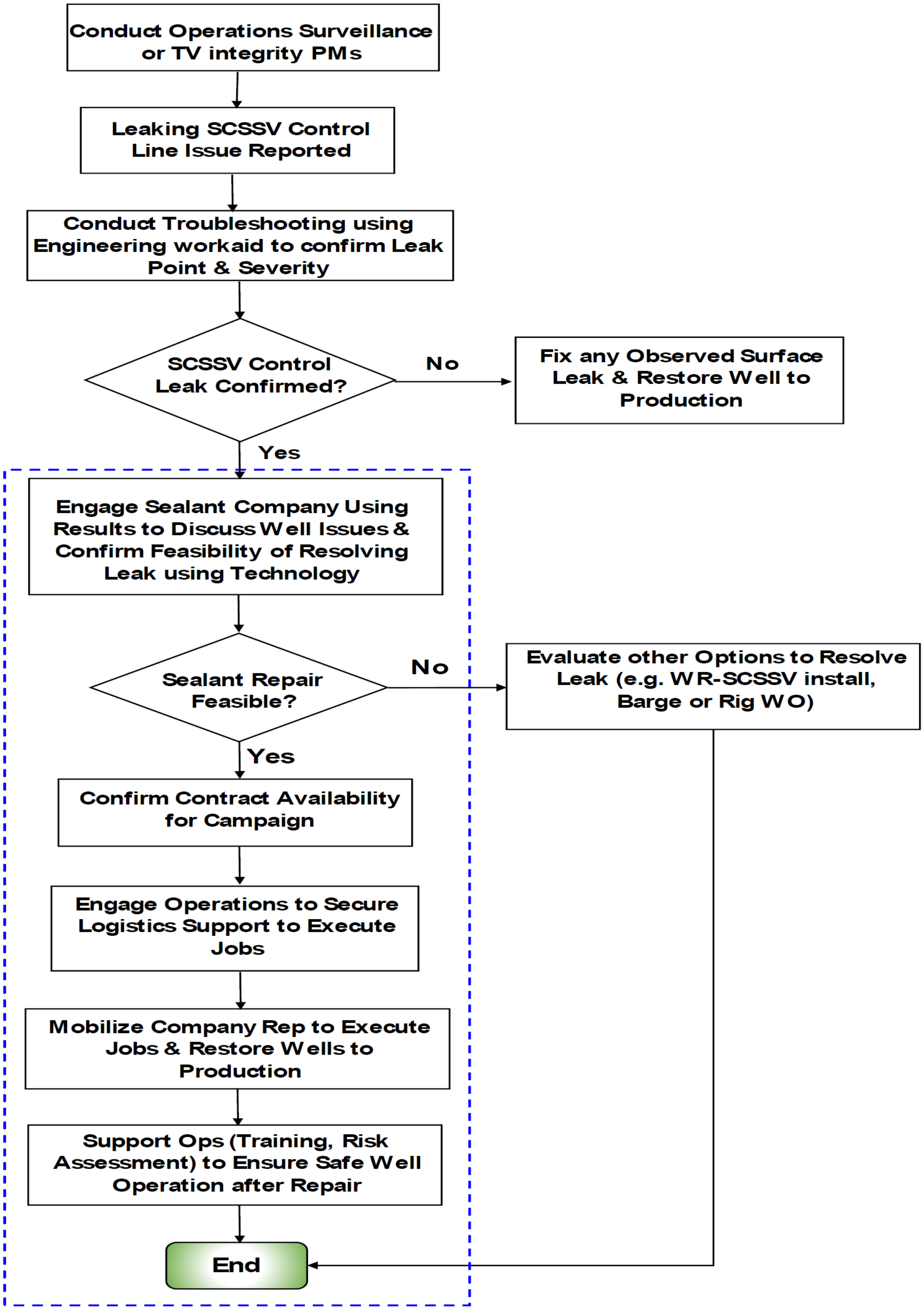

Figure 3—Sealant Treatment Workflow

Operational Statistics

Over the years, this method has been deployed in shallow and deep water (DW) fields and has achieved a success rate of about 90% from over 80 completed jobs. Increased success has been recorded on wells with considerable leak rates and within the threshold established mostly in shallow waters. Initial trials on a well in the DW field in 2011 proved abortive due to its several leak complexity and rate, which influence a more detailed and robust engineering process for DW water wells by the sealant company and MPN. To date, more jobs have been successfully completed in both the shallow and DW fields through utilization of the detailed treatment workflow presented. The chart below shows the workflow of sealant treatment execution in MPN wells over the years.

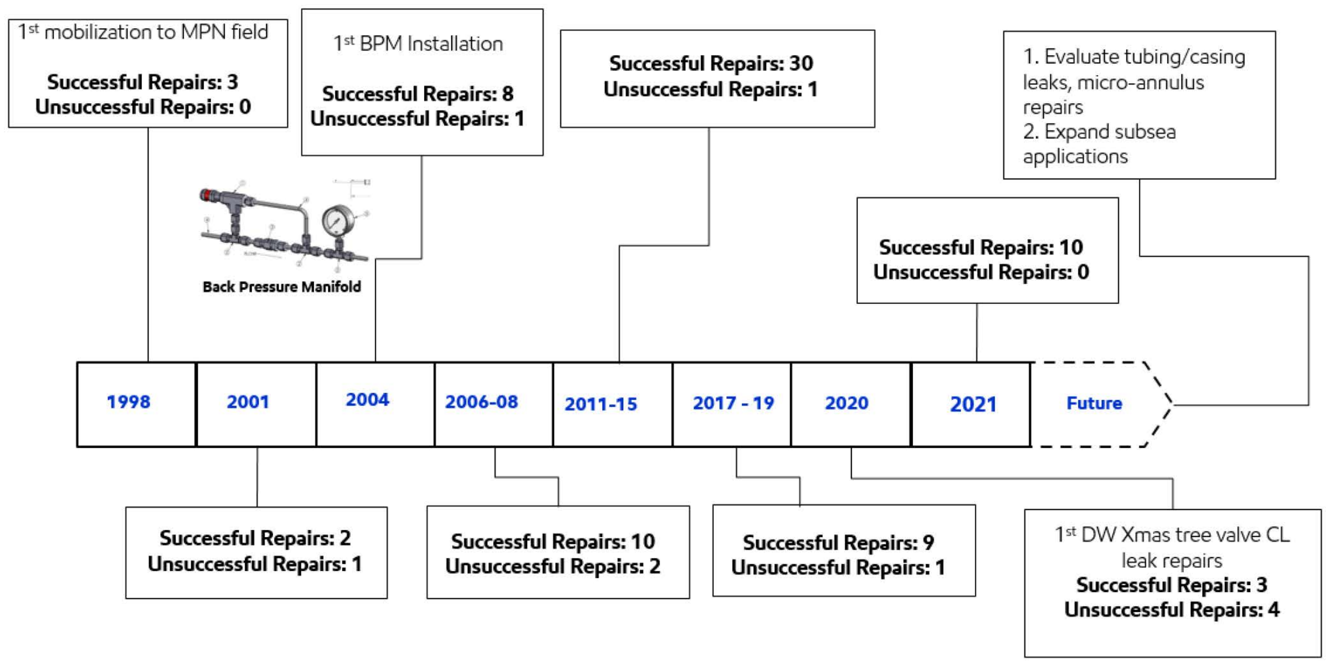

Figure 4—Sealant treatment campaign timelines in MPN

2021 MPN CASE STUDY

About 5% of the offshore shallow wells were identified as shut in due to SCSSV CL leaks across different producing platforms as of 2021. After detailed troubleshooting and engineering analysis, further well by well prioritization was completed based on three main criteria:

- Increased chance of restoration using technology
- Ability of well to flow once sealant has been pumped
- Volume incentive

Post troubleshooting and analysis the list of wells established for pressure activated sealant deployment were further truncated to 3%. The aim at the end of 2021 engineering selection process was to address CL leaks in at least 2% of wells in our shallow water fields, which were critical to sustaining production levels.

Sealant Treatment Operation

To ensure flawless execution during operations, the sealant personnel is required to follow the procedure and communicate any change to both MPN representative and sealant company before progressing with further steps. The execution phase involves a confirmatory leak diagnostics phase which was a critical determinant to check previous troubleshooting conducted on a well before proceeding with the treatment.

Confirmatory Leak Diagnostics

As a confirmatory check to the previous diagnostic performed using the platform SCSSV CL hydraulic panel, the sealant representative would typically perform a second diagnostic using a more sensitive pump with the ability to detect even smaller leaks along the closed system. The pump is connected to the CL and hydraulic fluid is pumped in to determine the severity and depth of the leak based on pressure loss along the line. Based on the results obtained, these re-affirmed results obtained previously and the sealant technology capability for the established wells.

Sealant Treatment Deployment

Once the confirmatory leak diagnostics was completed and a sealant job was required, the phase for deployment was next. This step involved pumping a certain volume of liquid sealant followed by hydraulic oil into the already existing control line through a hose connected to the sealant pump. Once leak site has been spotted and sealant displaced, the CL pressure is increased and monitored for any pressure loss as this would be indicative of a lack of sealing in the system. Monitoring the CL typically takes place for an hour and there are opportunities to reseal until a two-way seal is confirmed and a stable CL pressure has been achieved. On confirmation of a seal, an injection cylinder containing partitioned liquid sealant and hydraulic fluid is installed on the well.

The injection cylinder is typically a service item primarily used to inject sealant over the producing period of a well, post a sealant job to make up for any minor leaks developed or a compromised seal. It can also be used to prevent back flow from the SCSSV control line to the safety panel in a sealant repair application where a two-way seal (seal that holds pressure in both directions, from control line to well, and from well to control line) is not achieved. It consists of a polished bore cylinder with internal pistons and threaded end caps installed near the tree with a gauge between the needle valve and injection cylinder. The position of the piston in the cylinder is based on well conditions when installed by sealant representative and is tested to confirm the SCSSV closes properly during an ESD.

The cylinder is tested for functionality once installed by pressuring up the CL with the safety panel, perform surface leak checks and open up SCSSV for well to flow.

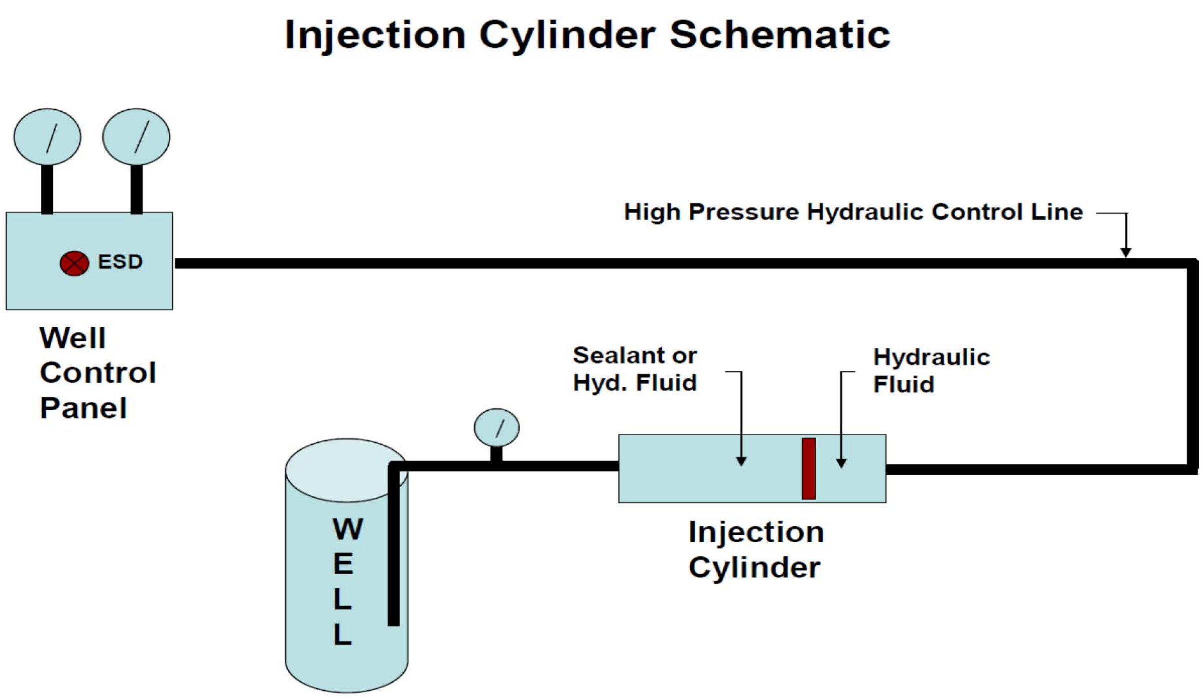

Figure 5—Diagram showing the location of the injection cylinder

Operational Summary

With the aid of the sealant treatment operation in 2021, MPN was able to utilize a low-cost sealant technology for SCSSV control line repairs in over 2% of our producing wells across 50% of our production platforms, which overall yielded safe volume restorations of ~ 6% (C&C and NGL) and proactively protected ~13% (wells flowing with early signs of a CL leak) of MPN overall volumes capacity at an optimized cost of approximately 12% the traditional spend for an WR-SCSSV barge intervention or rig-based tubing replacement workover.

Conclusion

The use of a pressure activated sealant technology to seal wellbore leaks and restore integrity has proven to be a cost-effective and efficient solution to seal leaks along SCSSV CL. Considering the deployment is made in a closed circuit, with no risk of environmental contamination and only requires a minimum of tools and personnel for its application, a leak can quickly be cured without the high-cost demand, risks, and delays of a rig intervention. With the use of this service, potential loss of production caused by SCSSV closing is completely avoided.

For a successful and safe job execution, it is crucial to conduct a detailed analysis of the well characteristics and leak condition before execution using an engineering tailored procedure.

References

1. Michael A. Romano Seal-Tite International and Giuseppe Rodero, Megadrill. Pressure-Activated Sealant Technology. A Cost-Effective Alternative to Conventional Leak Repair Methods. *SPE Technical Bulletin*: 31–34
2. David W. Rusch Seal-Tite International. Subsea Leaks Cured with Pressure-Activated Sealant, SPE Asia Pacific Oil and Gas Conference and Exhibition, Perth, Australia, 18–20, October 2004, SPE 88566