LIFT SYSTEMS FOR CASING PRODUCTION WITH AUTOMATION

DAVID GREGG
MULTI PRODUCTS COMPANY
AND
RON C. BISHOP
CONOCO

INTRODUCTION

THERE ARE CURRENTLY SEVERAL THOUSAND CASING PLUNGER LIFT SYSTEMS INSTALLED IN VARIOUS PARTS OF THE COUNTRY. THEY RANGE FROM VERY SUCCESSFUL TO FAILURES. THIS PAPER IS AN ATTEMPT TO EXPLAIN WHY THIS HAS BECOME THE CASE AND TO DELINIATE ISSUES OF WHERE TO APPLY THIS TECHNOLOGY.

THE APPLICATION OF THIS TYPE OF ARTIFICIAL LIFT DESIGN MUST REQUIRE THE USE OF SOME PLANNING THAT IS NOT COMMON TO THE NORMAL TUBING PLUNGER LIFT DESIGNS. THERE ARE FEW SIMILARITIES BETWEEN THE TUBING PLUNGERS AND THEIR CONCEPT OF OPERATION AND WHAT OCCURS WITH THE CASING PLUNGER AND ITS OPERATIONAL CONCEPT.

THE USE OF THE TUBING PLUNGER LIFT SYSTEM IS BASED IN FACT THAT THERE IS SUFFICIENT GAS FLOWING AT A HIGH RATE TO BRING THE COLUMN OF LIQUIDS ACCUMULATED IN THE TUBING STRING TO THE SURFACE. THE FLOW RATE IS AN ISSUE OF SUFFICIENT PRESSURE AND VOLUME TO ALLOW THIS TO CREATE A VELOCITY THAT CREATES A GAS/LIQUID SLUGGING. THE BALANCE OF THE VOLUME AND PRESSURE MUST BE ABLE TO DEVELOP THIS RATE AND OVERCOME THE HYDROSTATIC PRESSURE OF THE LIQUID COLUMN.

THE INACCURATE BALANCE OF EITHER THE LIQUID COLUMN OR THE VOLUME OF THE GAS OR THE PRESSURE OF THE GAS IN THE WELL OR IN THE VARIATION OF LINE PRESSURE CAN LEAD TO FAILURE. THE UNDERESTIMATING OF LIQUID OR AVAILABLE GAS OR FLUCTUATION OF LINE PRESSURE LEADS TO THE FLOW RATE BEING INSUFFICIENT OR THE FLOW BEGINNING BUT FAILING TO MAINTAIN THE TRAVEL TO HE SURFACE OF THE COLUMN AND PLUNGER. EXCESSIVE LIQUID OR DROPS IN WELL GAS VOLUME AND PRESSURE OR AN INCREASED LINE PRESSURE CAUSING PARTIAL LIQUID REMOVAL CAN BE TERMED PLUNGER "STALL".

OPERATORS PURPOSELY, YET UNDERSTANDABLY, AVOID THIS INBALANCE THAT CAN LEAD TO NO FLOW OR NO LIQUID UNLOADING FROM THE WELL. THE ACTUAL REQUIREMENTS OF THE CYCLE ARE OVERESTIMATED BY FACTORING IN TOO MUCH GAS FOR THE ACCUMULATED LIQUID COLUMN AND THEN ASSURING THE LIQUIDS AND PLUNGER WILL ARRIVE.

THIS APPROACH IS VERY COMMON TO WELL OPERATORS USING A TIME CYCLE CONTROLLER. WHILE THIS "OVERKILL" IS ASSURING THE SUCCESSFUL OPERATION OF THE CYCLE, IT LEADS TO THE FOLLOWING.

1. ACTUAL VALVE OPEN TIME BEING LESS THAN OPTIMUM TO INHIBIT LIQUIDS ACCUMULATING IN THE TUBING.
2. ACTUAL VALVE CLOSE TIME BEING MORE THAN REQUIRED ACCUMULATING PRESSURE AND VOLUME.
3. CREATING A SITUATION OF PRESSURE DROP FROM FLOW "SURGING" LIQUIDS INTO TUBING AND THEN A SHUTIN TO BUILD PRESSURE THAT IS FORCING LIQUIDS BACK INTO THE FORMATION AT THE WELL BORE.

THESE ISSUES HAVE BEEN ADDRESSED BY THE USE OF THE CASING PLUNGER. THE ISSUES HAVE BEEN MINIMIZED BY THE USE OF ITS POSITIVE SEALING APPARATUS *TO* USE GAS VOLUME AND PRESSURE AVAILABLE. THEY HAVE ALSO ALLOWED A "CONTINUOUS FLOW" CONDITION TO EXIST FOR THE WELL TO ALLOW FOR FLOW 24 HOURS PER DAY.

WHILE THE CONSTANT FLOWING OF THE WELL WAS AN ADVANCEMENT TO MANY, THE RESTRICTIONS PLACED ON THAT CONSTANT FLOW WERE A SERIOUS OPERATING CONSTRAINT *TO* OPTIMIZATION FOR MANY OPERATORS. THIS ISSUE WAS ONE OF THE MAJOR NEGATIVE ISSUES OF CONSIDERATION FOR CASING PLUNGER SYSTEMS. THAT ISSUE HAS BEEN ADDRESSED IN THIS PAPER AND DEALS WITH THE DESIGNS USED TO OVERCOME THIS AND OTHER NEGATIVE ITEMS.

THE USE OF AN AUTOMATED DESIGN NOW ALLOWS FOR THE SAFE AND RELIABLE USE OF THE CASING PLUNGER. THE SIGNIFICANT PRODUCTION INCREASES, THAT WERE NOT POSSIBLE BEFORE, ARE NOW A COMMON BENEFIT OF THE DESIGN.

THE REALIZATION THAT A LOW COST METHOD OF OPERATING A WELL THROUGH TO THE POINT OF PLUGGING AND ABANDONMENT HAS BEEN SEEN AS A RESULT OF USING THIS TYPE OF LIFT SYSTEM.

(PROBLEM ISSUES THAT ORIGINALLY WERE ENCOUNTERED USE OF A CASING PLUNGER.

ISSUE #1 THE SEALS OF THE CASING PLUNGER'S POSITIVE SEAL HAVE NOT BEEN ABLE TO OPERATE FOR A LONG PERIOD DUE TO BLISTERING AND SWELLING IN THE CASING. THIS HAS BEEN MOST NOTED ON FREE-CYCLE PLUNGERS.

ISSUE #2 THE FLOW IS RESTRICTED TO ALLOW THE CASING PLUNGER A SAFE RATE OF TRAVEL INTO THE LUBRICATOR AT THE SURFACE AND TO FALL FROM SURFACE TO THE BOTTOM HOLE STOP WITH THE CASING PLUNGER'S INTERNAL BY-PASS OPEN UNTIL THE PLUNGER CONTACTS THE DOWNHOLE STOP. THIS SAME RESTRICTED RATE HAS ALSO MADE THE WELL FLOW AT FAR BELOW ITS ABILITIES AFTER THE CASING PLUNGER HAS BEEN LOCKED INTO THE LUBRICATOR.

ISSUE #3 THE OPERATION OF THE SYSTEM REQUIRES THE USE OF A CASING PLUNGER LATCH ON THE LUBRICATOR AT THE SURFACE TO LOCK AND HOLD THE PLUNGER REQUIRING THAT THE OPERATOR ON LOCATION TO INITIATE THE NEXT CYCLE.

ISSUE #1 *THE SEALS OF THE CASING PLUNGER'S POSITIVE SEAL HAVE NOT BEEN ABLE TO OPERATE FOR A LONG PERIOD DUE TO BLISTERING AND SWELLING IN THE CASING.*

THE FOLLOWING IS A LIST OF THE FACTS THAT HAVE BEEN DETERMINED FROM USE OF THE CASING PLUNGER DESIGN. **HERE ARE SOME ESTABLISHED FACTS FROM THIS DATA THAT CAN BE SUPPORTED. SEE FIGURE 1.**

1. THIS INFORMATION IS BASED UPON WEIGHT OF COLUMN TO THE PRESSURE SEALED UNDER THE TOOL. (HYDRAULICS) EX: WEIGHT OF GALLON OF WATER = 8 TO 10 LB. PER GALLON. MAX. WEIGHT FOR BRINE WATER IS 420 LB. PER BARREL.

2. CROSS SECTION OF 4 INCH CASING IS 12.5 IN.'. 10 PSI. CAN LIFT 125 LB. USE THIS TO DETERMINE HOW MUCH LIQUID THE PRESSURE OF THE WELL CAN LIFT. THEREFORE, 100 PSI CAN LIFT 1250 LB.

3. CROSS SECTION OF 5 INCH CASING IS 19.6. 10 PSI CAN LIFT 196 LB. USE THIS TO DETERMINE HOW MUCH LIQUID THE PRESSURE OF THE WELL CAN LIFT. THEREFORE 100 PSI CAN LIFT 1960 LBS.

NOTE: *THIS IS NOT USED TO DETERMINE WHEN TO ALLOW THE AUTOMATED SYSTEM TO DROP THE PLUNGER AS MUCH AS WHEN THE CASING PLUNGER WILL WORK ON A WELL.*

ALSO SEE FIGURE 2 AT BACK OF PAPER.

THE CASING PLUNGER ELASTOMER SEALS ARE DIRECTLY AFFECTED BY THE AMOUNT OF DIFFERENTIAL PRESSURE SEEN BETWEEN THE TOP OF THE SEALS AND PRESSURE REQUIRED FROM BELOW.

EXAMPLE: 1- ABOVE THE SEALS IS A COLUMN OF LIQUIDS.

2. THE CASING PLUNGER MUST LIFT THAT WEIGHT BY THE BUILDING OF A PRESSURE BELOW SUFFICIENT TO MOVE OR LIFT THAT LIQUID COLUMN.
3. THE LIQUID COLUMN MOVES TO THE SURFACE WITH VERY LITTLE PRESSURE DIFFERENTIAL BETWEEN THE TOP AND THE BOTTOM OF THE SEALS.
4. THE LIQUID COLUMN NOW BEGINS TO UNLOAD DOWN INTO THE FLOW LINE.
5. AS THE WEIGHT BECOMES LESS ABOVE THE PLUNGER SEALS, THE PRESSURE BELOW THE SEALS IS THE SAME AS WHEN STARTED.
6. THE DIFFERENTIAL PRESSURE IS INCREASING DUE TO THIS DROP AT THE TOP OF THE SEALS AND STATIC PRESSURE BELOW THEM.
7. THE SEAL STRESS IS GREATEST AT THE VERY SURFACE WHEN ALL LIQUID IS OUT OF CASING AND JUST PRIOR TO THE PLUNGER'S INTERNAL BYPASS VALVE OPENING BY CONTACT WITH THE LUBRICATOR BUMPER.
8. THIS IS WHERE THERE CAN BE PROBLEMS.

BY ALLOWING THE CASING PLUNGER TO REMAIN AT THE SURFACE AND THE SEALS TO BECOME ADAPTED TO THE LOW PRESSURE WITH NO FLOW OR LIQUIDS, THE SEALS CAN AGAIN RETURN TO A STATE OF BECOMING NORMAL.

ISSUE #2 THE FLOW IS RESTRICTED TO ALLOW THE CASING PLUNGER A SAFE RATE OF TRAVEL INTO THE LUBRICATOR AT THE SURFACE AND TO FALL FROM SURFACE TO THE BOTTOM HOLE STOP WITH THE CASING PLUNGER'S INTERNAL BY-PASS OPEN UNTIL THE PLUNGER CONTACTS THE DOWNHOLE STOP. *THIS SAME **RESTRICTED RATE** HAS ALSO MADE THE WELL FLOW AT FAR **BELOW ITS ABILITIES** AFTER THE CASING PLUNGER HAS BEEN **LOCKED** INTO THE LUBRICATOR.*

THIS ISSUE IS BEST DESCRIBED AS HOW TO SAFELY BRING THE PLUNGER TO THE SURFACE AND YET PRODUCE **NUMBER OF CYCLES WELL CAN MAKE WITH CASING PLUNGER PER DAY. A CYCLE IS BEING DEFINED AS LATCH TO LATCH.***

***CYCLE = TOTAL OF TIME LATCHED AT SURFACE** + TIME TO FALL + TIME FOR RETURN ASCENT TO LATCH.**

****NOTE:** THE TIME THE CASING PLUNGER IS LATCHED AT THE SURFACE IS SAME TIME THE MOTOR VALVE IS OPEN TO SALES.**

THE CYCLE IS TOTAL TIME FOR THE PLUNGER FROM ITS ARRIVAL AT THE SURFACE UNTIL IT ARRIVES AGAIN. THIS IS A FACTOR OF DEPTH THE PLUNGER MUST FALL TO GET TO BOTTOM AND THE TIME IT TAKES FOR IT TO LAND ON THE STOP AND BEGIN ITS ASSCENT.

THE MOST CRITICAL FACTOR IS TO ALLOW THE CASING PLUNGER SUFFICIENT TIME AT THE SURFACE TO "NORMALIZE" THE ELASTOMERIC SEAL CUPS. THE HIGHER THE PRESSURE OF THE WELL, THE LONGER THE TOOL NEEDS TO STAY AT THE SURFACE. THIS IS NOT PROPORTIONAL SO A SAMPLE TABLE IS GIVEN. **(SEE FIGURE 3).**

TABLE OF NORMALIZE TIME FOR SEALING ELEMENTS. *(THE TIME AUTOLATCH SHOULD HOLD THE PLUNGER AT SURFACE.*

THIS TABLE IS BASED UPON THE CASING PLUNGER BEING USED WITH THE FULL AUTOMATION SYSTEM AND NOT ALLOWING THE TOOL TO FREE TRAVEL OR SIT ON THE BOTTOM AT THE CASING STOP. THIS PRACTICE WILL PROVE TO BE COSTLY AND NON-PRODUCTIVE AS THE PLUNGER CUPS WILL ABSORB THE HIGHER PRESSURES AND FAIL TO TRAVEL TO THE SURFACE.

NOTE: THIS NORMALIZE TIME IS SALES TIME WITH THE SALES VALVE OPEN. THIS IS NOT LOST TIME!

THIS TABLE TELLS THE TIME FRAME REQUIRED TO HAVE THE POSITIVE SEAL CASING PLUNGER SETTING AT THE SURFACE TO ALLOW THE ELASTOMERIC CUPS TO STABILIZE. THIS IS NECESSARY TO ASSURE THE CUPS ARE NOT IMPREGNATED WITH PRESSURE THAT CAN INFLATE THEM TO BEYOND THEIR NORMAL DIMENSION.

*BEAR IN MIND, THAT THIS IS **ALSO** THE SALES TIME OF THE **WELL** AND IS BEST RECOGNIZED **AS** THE WELL PRODUCTION TIME. DURING THIS TIME FRAME THE **FLOW** VALVE IS OPEN AND SALES ARE AT THEIR MAXIMUM.*

FALL RATE HAS BEEN DETERMINED TO BE BETWEEN 10 AND 14 MINUTES PER THOUSAND FEET OF CASING IN WELLS WITH GOOD INTEGRITY OF THE CASING ID. THE NUMBER OF PORTS OPENED TO FLOW IN THE PLUNGER'S INTERNAL BYPASS CAN ALSO MAKE A DIFFERENCE.

FALL TIME = TIME FOR PLUNGER TO FALL FROM SURFACE, WHEN RELEASED, TO THE CASING COLLAR STOP.
ALWAYS USE WORSE CASE FOR THE INITIAL DESCENT OF THE CASING PLUNGER.

TO DETERMINE CYCLE TIME FOR INITIAL SETUP

ISSUE #3 *THE OPERATION OF THE SYSTEM REQUIRES THE USE OF A CASING PLUNGER LATCH IN THE LUBRICATOR AT THE SURFACE TO LOCK AND HOLD THE PLUNGER. THIS REQUIRES THE OPERATOR ON LOCATION TO INITIATE THE NEXT CYCLE.*

(CASING PRESSURE NORMALIZE TIME FROM TABLE)+ (MAXIMUM FALL RATE PER THOUSAND) + (RATE OF ASSCENT TO THE SURFACE.)= CYCLE TIME.
EXAMPLE: 300 PSI MEANS A 240 MINUTE WAIT ON THE PLUJNGER PLUS A FALL TIME OF (3770/1000 OR) 3.77 x 14 MIN. PER 1000 FOR A TOTAL OF 293 MINUTES *PLUS* TRAVEL TIME TO THE SURFACE OF ABOUT 20 TO 30 MINUTES = CYCLE TIME.

TO DETERMINE THE NUMBER OF CYCLES PER DAY

CYCLE TIME/1440 = NUMBER OF CYCLES PER DAY.**
***1440 = NUMBER Of MINUTES PER **24** HOUR **DAY.** DIVIDE CYCLE TIME IN MINUTES INTO THIS TO GET TOTAL CYCLES.*

YOU CAN CLEARLY SEE THAT WE ARE AT ABOUT 5 CYCLES PER DAY. THE 300 PSI CASING PRESSURE WILL LIFT 7.5 BARRELS PER CYCLE. THIS MEANS THE CASING PLUNGER WILL PRODUCE CLOSE TO 40 BARRELS PER DAY. IF THE WELL IS CURRENTLY PRODUCING LESS THAN THIS, YOU SHOULD HAVE GOOD RESULTS FROM THESE VALUES.

POTENTIAL VOLUME OF GAS THAT CAN BE DELIVERED TO THE GATHERING SYSTEM AT A GIVEN CASING PRESSURE WITH A KNOWN LINE PRESSURE WITH USE OF A POSITIVE SEAL CASING PLUNGER.

THE USE OF A "FAIL SAFE" CONTROLLER AND A LARGE PORT MOTOR VALVE WITH THE CASING PLUNGER SYSTEM ALLOWS FOR THE MAXIMIZING OF FLOW WHILE OFFERING SAFETY AND SECURITY IN THE TRAVEL OF THE CASING PLUNGER INTO THE LUBRICATOR. THIS DESIGN MUST ASSURE THE LARGE PORT MOTOR VALVE CAN NEVER BE OPENED DURING TRAVEL OF THE PLUNGER. THIS WOULD CREATE AN INCREASED VELOCITY OF THE PLUNGER THAT MAY DAMAGE SURFACE EQUIPMENT AND VALVES.

THE LARGER ORIFICE MOTOR VALVE HAS AN FLOW ORIFICE OF 1 ¼". THIS CAPACITY IS THE FACTOR USED TO DETERMINE HOW MUCH GAS CAN BE SOLD TO THE GATHERING SYSTEM. USING THE WELL CRITERIA GIVEN OF 65 PSI LINE PRESSURE AND A CASING PRESSURE OF AN AVERAGE OF THE PSI FROM A LOW TO A HIGH, WE CAN MAKE CHART. THIS CHART IS BASED UPON THE RATE OF FLOW ABLE TO PASS THROUGH A GIVEN ORIFICE WITH A GIVEN LINE PRESSURE.

NOTE: *REMEMBER THAT THE HIGHER RATES OCCUR DURING THE TIME THE POSITIVE SEAL CASING PLUNGER IS LATCHED AT THE SURFACE IN THE LUBRICATOR. THIS IS WHEN THE VALVE IS ALLOWED TO OPEN.*

WE ARE USING 65 PSI AS LINE PRESSURE WITH ALL FLOW GOING TO THIS LINE. THE FLOW RATE IS CALCULATED TO A 1 ¼" ORIFICE. YOU MUST BE CERTAIN TO DEDUCT LINE PRESSURE FROM THESE CASING PRESSURES.

NOTE: LINE PRESSURES ARE NOT NORMALLY CRITICAL WITH THE NEWLY DESIGNED CANSING PLUNGERS AS LONG AS THE PLUNGER WELL HAS SUFFICIENJPRESSURE JO LIFT THE LIQUIDS AGAINST THAT PRESSURE.

THE POTENTIAL VOLUME OF LIQUID THAT CAN BE DELIVERED TO THE GATHERING SYSTEM AT A GIVEN PRESSURE FROM THE WELL FORMATION WITH THE POSITIVE SEAL CASING PLUNGER FOR **4 ½".**

LIQUID VOLUME/CYCLE = (CASING PRESSURE – LINE PRESSURE) X 12.5 IN.' /420 LBS.

. THE 300 PSI CASING PRESSURE WILL LIFT 7.5 BARRELS PER CYCLE. THIS MEANS THE POSITIVE SEAL **4 ½"** CASING PLUNGER WITH 5 CYCLES WILL PRODUCE CLOSE TO **40** BARRELS PER DAY.

WITH 6 CYCLES 45 BBLS/DAY
WITH 7 CYCLES 52 BBLS/DAY
WITH *8* CYCLES 60 BBLS/DAY

THEREFORE:
13 BARRELS OF LIQUID MADE BY A WELL CAN BE REMOVED IN TWO CYCLES AT 300 PSI
OR
4 TO 5 CYCLES AT 150 PSI.

THE POTENTIAL VOLUME OF LIQUID THAT CAN BE DELIVERED TO THE GATHERING SYSTEM AT A GIVEN PRESSURE FROM THE WELL FORMATION WITH THE POSITIVE SEAL CASING PLUNGER FOR **5 ½".**

LIQUID VOLUME/CYCLE = (CASING PRESSURE – LINE PRESSURE) X 19.6 IN.' /420 LBS.

THEREFORE:
300 PSI CASING PRESSURE WILL LIFT 13.9 BARRELS PER CYCLE. THIS MEANS THE POSITIVE SEAL **5 1/2"** CASING PLUNGER WITH 5 CYCLES WILL PRODUCE CLOSE TO 69 BARRELS PER DAY.

WITH 6 CYCLES 83 BBLS/DAY
WITH 7 CYCLES 97 BBLS/DAY
WITH 8 CYCLES 111 BBLS/DAY

CONCLUSIONS

THE VOLUMES AND RATES ATTRIBUTED TO THE USE OR THE AUTOMATED SYSTEM WITH THE LARGE PORT MOTOR VALVE EQUATE TO A METHOD THAT IS CAPABLE OF DELIVERING THE VOLUMES THAT MAKE THIS DESIGN NOT ONLY SUCCESSFUL BUT MANDATORY.

THE USE OF THE "FREE CYCLE" TYPE OF OPERATION WITH THE CASING PLUNGER IS NEVER SAFELY GOING TO BE DELIVERING THE RATES THAT ARE SHOWN IN THIS PAPER. THIS IS DUE TO THE COMPROMISES PLACED ON THE TOOL TRAVEL TO MAKE THE SYSTEM SAFE. THE CASING PLUNGER IS TOTALLY OUT OF THE FLOW RATES INFLUENCE WHEN IT IS SAFELY "LOCKED" INTO THE LUBRICATOR. THIS IS THE TIME FOR THE WELL TO BOTH PRODUCE AT MAXIMUM RATES AND ALSO ALLOW THE PLUNGER SEALS, IF NECESSARY, TO BECOME NORMAL.
THE WELL SHOWN IN THIS EXAMPLE IS CAPABLE OF SUSTAINING A DEFINITE PRODUCTION INCREASE WITHIN THE FIRST WEEK OF THE OPERATION WITH THE POSITIVE SEAL CASING PLUNGER AUTOMATED SYSTEM. IT WILL SHOW AN INCREASE IN LIQUID PRODUCTION FOR A PERIOD OF TIME THAT COULD BE AS LITTLE AS 48 HOURS AND AS LONG AS A WEEK.

THIS WILL THEN DIMINISH AND GAS RATES WILL ACHIEVE A SIGNIMICANTLY HIGHER RATE THAT CAN BE SUSTAINED FOR THE DURATION.

THE UFESPAN OF THE SYSTEM ON THE WELL IS QUITE EXTENSIVE. THIS IS DUE TO THE FACT THAT THE CURRENT AVAILABLE PRESSURE ON THE WELL IS MORE THAN SUFFICIENT TO HANDLE THE LIQUIDS AND FLOW AGAINST LINE PRESSURE. THIS WELL SHOWS THAT THE SAME LIQUID LOAD CAN BE HANDLED BY THE PLUNGER UNTIL THE WELL PRESSURE DEPLETES TO BELOW 110 PSI.

THIS IS DUE TO THE FACT THAT LESS TIME IS REQUIRED IN NORMALIZATION AT THAT PRESSURE. THIS MEANS MORE CYCLES.

THIS CRITICAL ISSUE THAT IS YET NOT RESOLVED, IS THE CONDITION OF THE CASING ID AND ITS INTEGRITY. THIS SHOULD BE DETERMINED BEFORE ANY FURTHER EXPENDITURESARE MADE. SHOULD THE CONDITION OF THE PIPE BE ACCEPTABLE, THE APPLICATION OF THE SYSTEM EQUIPMENT SHOULD BE COMPLETED SEVERAL HOURS AFTER STARTED.

PENDING THAT APPROVAL AND DETERMINATION, THE RESULTS SHOULD BE VERY MUCH A SUCCESS. THAT CRITERIA USED TO DEFINE FOR SUCCESS NEEDS TO BE CLARIFIED PRIOR TO COMMITMENT. THE DEFINITION OF SUCCESS IS NOT THE SAME WITH ALL PEOPLE AND ORGANIZATIONS. THE ABILITY OF THE WELL TO INCREASE PRODUCTION TO ALLOW THE EQUIPMENT AND COSTS TO BE PAID IN 3 MONTHS IS A SUCCESS.

BIBLIOGRAPHY

CRAMER, JOHN W., P.E., SPE AND WOOD, DANIEL D. SPE: SOCIETY OF PETROLEUM ENGINEERS PAPER #30981. AUTOMATIC CASING SWABS: A PRODUCTION SYSTEM THAT CAN ADD YEARS OF PRODUCTIVE LIFE TO WELLS SEPTEMBER 17, 1995. SPE EASTERN REGIONAL MEETING; MORGANTOWN, WV.

HAYNES, C. D.; CORP, J. G. AND MILLER, T. C. SPE. SOCIETY FO PETROLEUM ENGINEERS PAPER #21695. FIELD EXPERIMENTS WITH AUTOMATIC CASING SWABS APRIL 7, 1991. SPE PRODUCTION OPERATIONS SYMPOSIUM; OKLAHOMA CITY, OK.

ACKNOWLEDGEMENTS

APPRECIATION IS EXTENDED TO CONOCO FOR ITS TREMENDOUS ASSISTANCE AND INPUT INTO THE TESTING AND EVALUATION OF THE MATERIALS AND RESULTS OF THE DESIGNS AND DEVELOPMENTS. THIS IS EXPRESSLY TO RON BISHOP FOR HIS PATIENCE AND EXTREMELY INSIGHTFUL SUGGESTIONS AND EXPERTISE.

AND ALSO TO WILLIAM BAKER OF MULTI PRODUCTS COMPANY FOR HIS INPUT AND GENEROSITY IN PROVIDING EQUIPMENT, DOCUMENTS AND PERSONNEL TO DEVELOP AND SUPPLY PROTOTYPES AND COMPONENTS TO FURTHER THE DEVELOPMENT OF THIS SYSTEM.

TREMENDOUS APPRECIATION ALSO EXTENDED TO THE PRODUCERS WITH THE INSIGHT AND FORTITUDE TO INSTALL AND TEST THE DESIGNS. IT IS THROUGH THIS FORESIGHT THAT WE HAVE SEEN SO MANY OF THE CURRENT DEVELOPMENTS IN TECHNOLOGY BECOME TRUE WORKING PRODUCTS THAT WE ALL CAN UTILIZE.

AVAILABLE		
50	1.48	2.32
100	2.9	4.64
150	3.3	6.96
200	4.7	9.28
250	6.1	11.6
300	7.5	13.92
350	8.9	16.24
400	9.3	18.56

Figure 1 - This Table shows the amount of liquid in barrels that a given pressure that exceeds line pressure can lift to the surface.

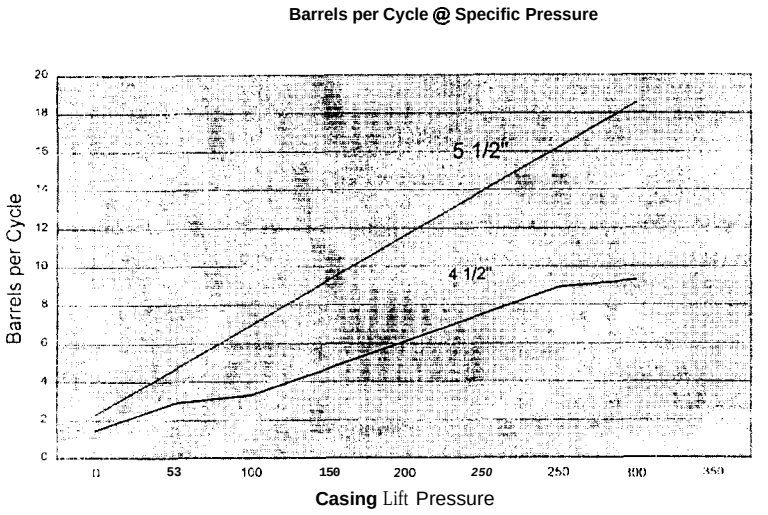

Figure 2 - Liquids that can be Lifted by the Casing Plunger Using Available Formation Pressure Minus Gathering System Pressure

NORMALIZE** CASING PSI	TIME (MINUTES)
50	75
100	120
150	150
200	200
250	220
400	

** NORMALIZE IS THE TIME THAT THE SEALS MAY REQUIRE FOR DRYING AND RETURNING TO A NORMAL CONDITION OR STATE.

Figure 3 - Time Required to Allow Seals to Become Normal per Cycle at Given Pressure at Surface in Lubricator

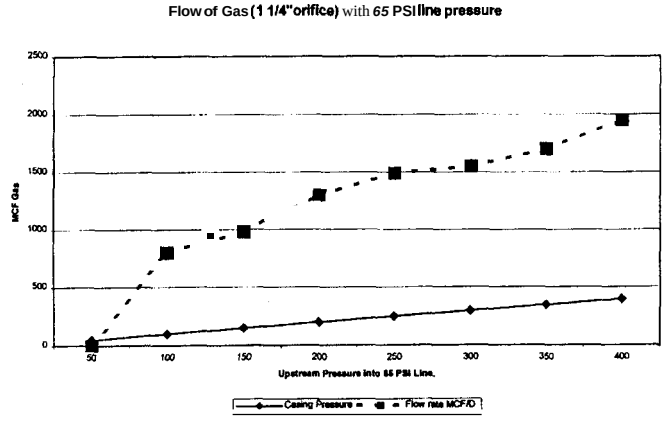

Figure 4 - Gas Rate Increase by Addition of Larger Motor Valve Orifices
Note that a fixed line pressure is used to show consistency.

FACTS FROM YOUR CANDIDATE WELL.

> CASING SIZE _____ INCHES
> VALVE INTERNAL DIAMETER _____ INCHES
> DEPTH _____ FEET
> FORMATION PRESSURE _____ PSI
> FORMATION TEMPERATURE _____ °F
> WELL MAKES _____ WAX. _____ SCALE _____ BRINE DEPOSITS _____ H_2S _____ CONDENSATE.
> CASING CONDITION FROM CALIPER LOG _____ GOOD; _____ SPOT PROBLEMS; _____ POOR.
> LIQUID RATE _____ BARRELS/DAY
> WATER CUT _____ %
> GAS RATE _____ MCF/DAY
> ONE DAY SHUT-IN _____ PSI
> LINE PRESSURE _____ PSI

Figure AA - Factor in the specifics of your candidate and apply the guidelines shown and discussed to determine your applications possible performance.