Pegasus Vertex, Inc.

Drilling Software | Sophisticated Yet Simple

WHITE PAPER

A Better Way to Capture and Manage Cement Lab Data

CONTENTS

I. Introduction

The design and test of cement slurries are integral parts of every cementing job. Variability between wells can make this process time-consuming and expensive. Traditionally, cementing engineers and lab technicians used paper files to record test results. The introduction of spreadsheet software, like Excel®, greatly enhanced the reporting quality and speed of filing. However, organizing numerous reports and searching those reports proved to be very difficult.

Without an interactive cement lab database, engineers and technicians face:

- Difficulty designing cement slurries
- Wasted resources when repeating similar tests
- Lack of proof of the design flaws while job problems occurred
- Difficulty maintaining standards across labs within the same company
- Extra work transferring designs to other people and testing data
- Difficulty keeping track of all in-process and finished design tests

II. Solution

To streamline the cement lab operation, PVI developed CEMLab, an integrated database management application that formulates slurries, calculates required weights for all ingredients (cement, dry and liquid additives, salts and water), generates weight-up sheets, stores test results, and generates lab reports.

This web-based application allows users to quickly access their slurry formulations and check testing status from anywhere, at any time. The advanced search function enables users to find the formula and the test they need, based on past jobs, in no time.

1. Engineering Features

CEMLab includes the following key features:

- Web-based application
- Slurry designs
- Spacer designs
- Centralized master database
- 7 API standard tests
- User-defined test
- Test sheet
- Final reports
- Search criteria
- Job tracking
- Test request
- Email notification
- Cost calculations

2. Program Structure

CEMLab is designed for different groups of users in mind. Fig. 1 shows the program flow chart with the involvement of an administrator, slurry specialist and lab technician.

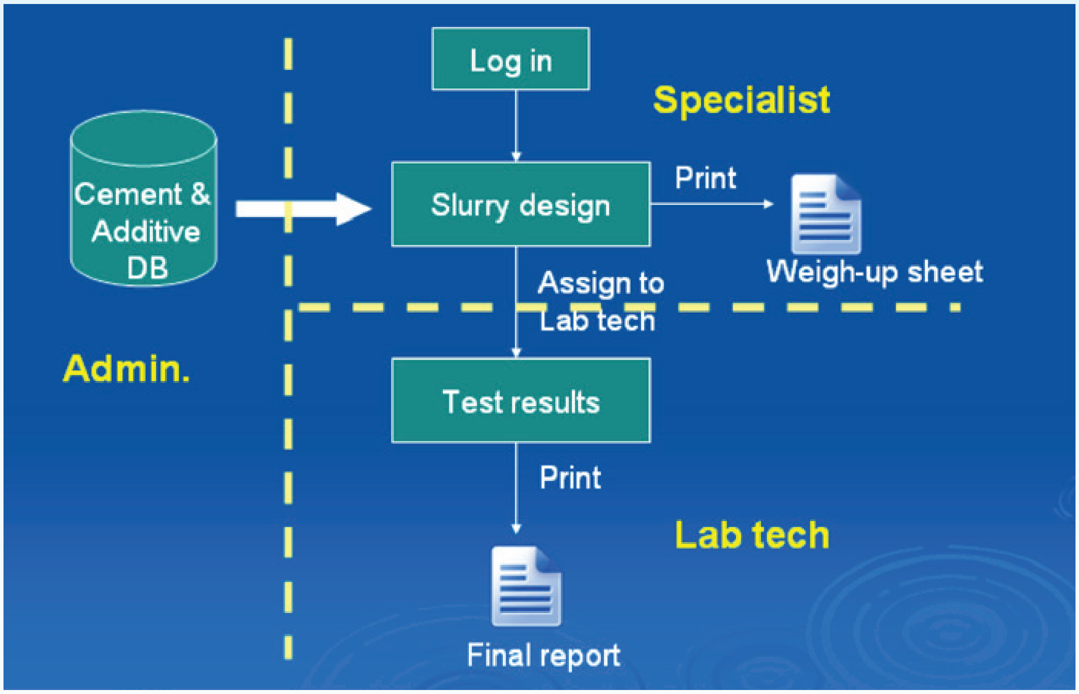


Fig. 1. Work Flowchart

The administrator, who has the highest privilege within the system, is in charge of the master database. The master database contains information about cements, chemical additives, and base fluids including code, SG, bulk density, price, etc. A general user can log into CEMLab and use the data in the master database to formulate cement slurries. After a slurry design is completed, the user can print out a test or weigh-up sheet and then assign the slurry design to another lab technician after selecting what tests are required. When the lab technician receives the test request, he can make the cement slurry as per the slurry formula and perform the requested tests. When this is completed, he then inputs the tests results into CEMLab and saves them. After all tests are done, the lab technician can return the test results back to the original designer for review. If the designer is satisfied with the test results, he can finalize the slurry design and print out a final report. If he is not satisfied with the test results, then he can make changes on his original design and send out a second test request. The lab technician and designer repeat this process until they have a qualified slurry design.

3. Interface

The user interface is arranged to accomplish the following tasks: **Design**, **Search**, **Master Database** and **Management**.

The Job Tracking section displays the following 4 stages of slurry design and testing (Fig. 2):

A. “Designing” – fluid designs that are currently in the design process.

B. “Testing” – fluid designs that are assigned to a certain user or to a whole lab for testing.

C. “Returned” – fluid design tests that have been completed by the technician and are returned to the original designer for review.

D. “Finalized” – fluid designs that have been completed and archived.

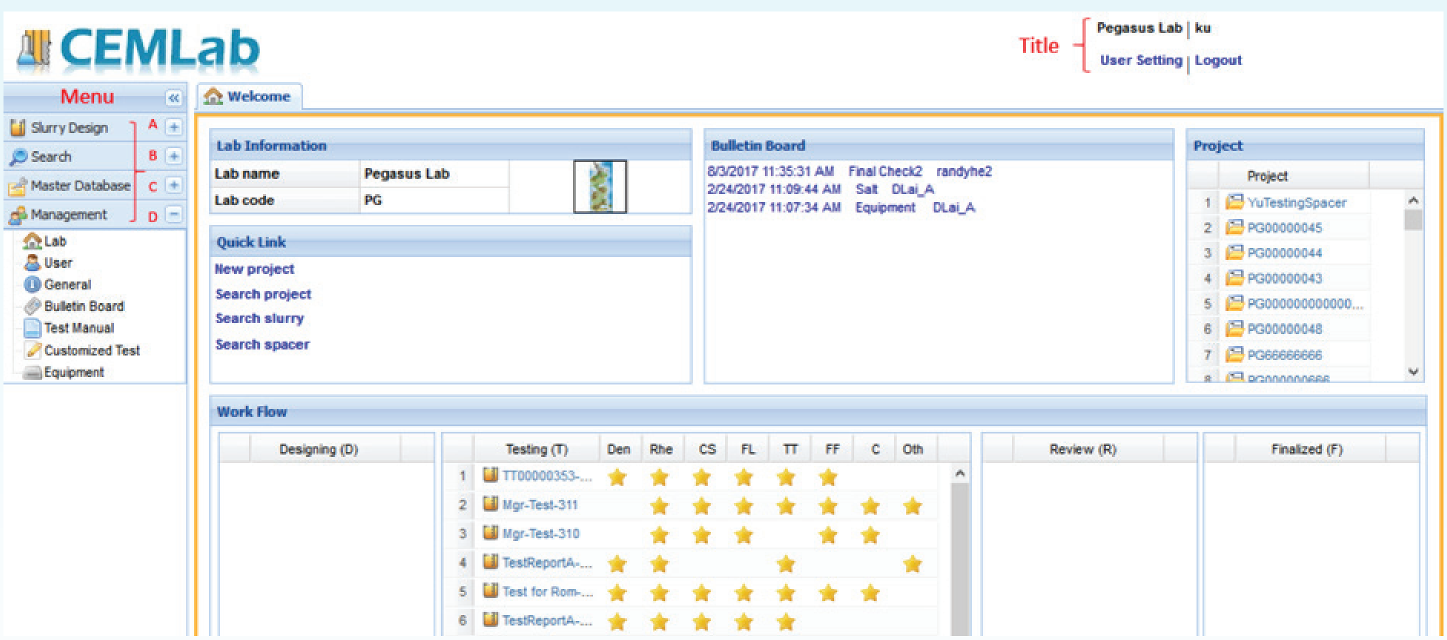


Fig. 2. Interface

4. Slurry Design

Users can use the following sections of blend, solid additive, liquid additive, and base fluid to achieve a slurry design. For example, the input table for blend is displayed in Fig. 3.

Fig. 3. Blend

The floating panel on the right side summarizes slurry parameters and calculated results. (Fig. 4)

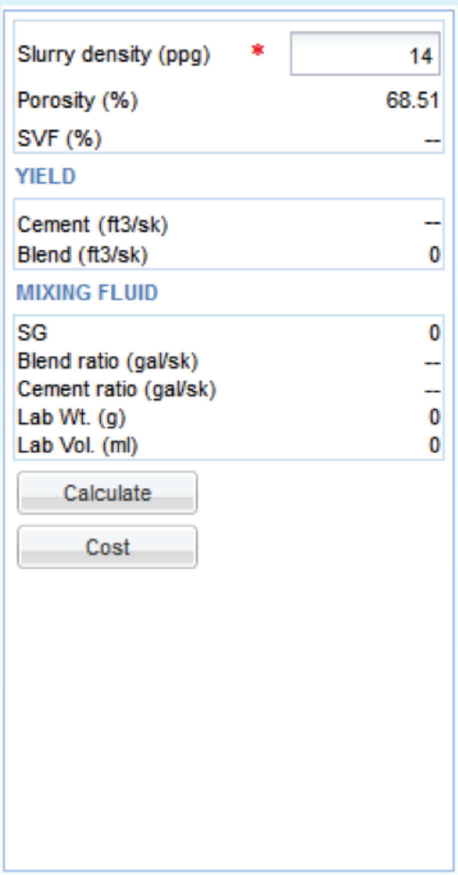


Fig. 4. Slurry property and results

For an entire cement slurry design, users can start with defining either a desired slurry density or a proper porosity. Porosity is the ratio between the volume of the ingredients in the liquid phase and whole cement slurry volume. In most cases, users would start with slurry density, but the flexibility to define the porosity can be very helpful. Users can see how the slurry density changes while adjusting the porosity value.

CEMLab allows users to input the concentration of an ingredient in various units: %BWOC, %BWOB, %BVOB, %BWOW, lb/sk, and gal/sk. Users can specify the unit for each ingredient. For example, the blend is in %BWOB, solid additives are in lb/sk, and liquid additives are in gal/sk. With the mixed unit system, users have the maximum flexibility to create a cement slurry formula.

Another flexible design of CEMLab is that it allows users to define the volume of slurry samples, which is normally 600 ml in most cases. Under some special circumstances, users may want to change it to some other volume. The software provides this option. After changing the volume, it will refresh the calculated results accordingly.

CEMLab can also calculate the cost of the cement slurry based on the given unit price of the ingredients. Furthermore, the ‘super sack’ function can help users calculate how much of each ingredient is required to make a large amount of a certain type of cement slurry and the total cost. Users also have an option to print out a ‘super sack’ report as a part of the final report.

At the bottom of the slurry design page, there is a ‘Comments’ section. Users can leave comments for a slurry design and other users can view, respond or write their own comments. There is also an ‘Attachment’ section for each slurry design which allows users to upload any format of files according to the slurry design. For example, test sheets and excel spreadsheets are a few of the permitted file types. The uploaded files will then be saved along with the slurry design, and can be downloaded at any given time.

5. Test

The program allows 7 API standard tests and one user defined test. (Fig. 5)

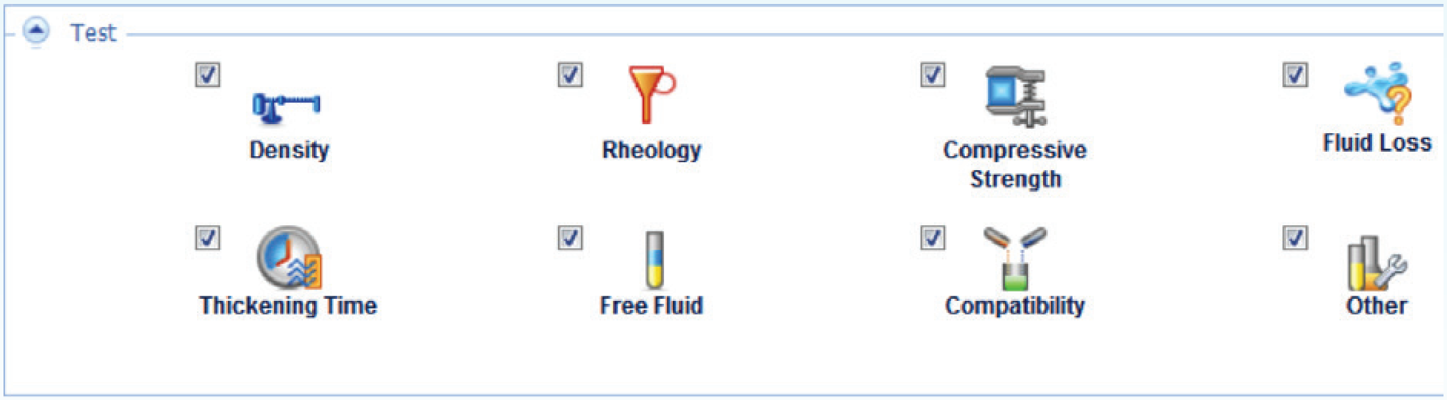


Fig. 5. Tests

For example, in the Rheology window, users can input the viscometer readings. (Fig. 6) The system will calculate and show the results, and plot the shear rate vs. shear stress graph on the right side. The system handles 3 rheological models: Bingham plastic, Power law, and Herschel Bulkley.

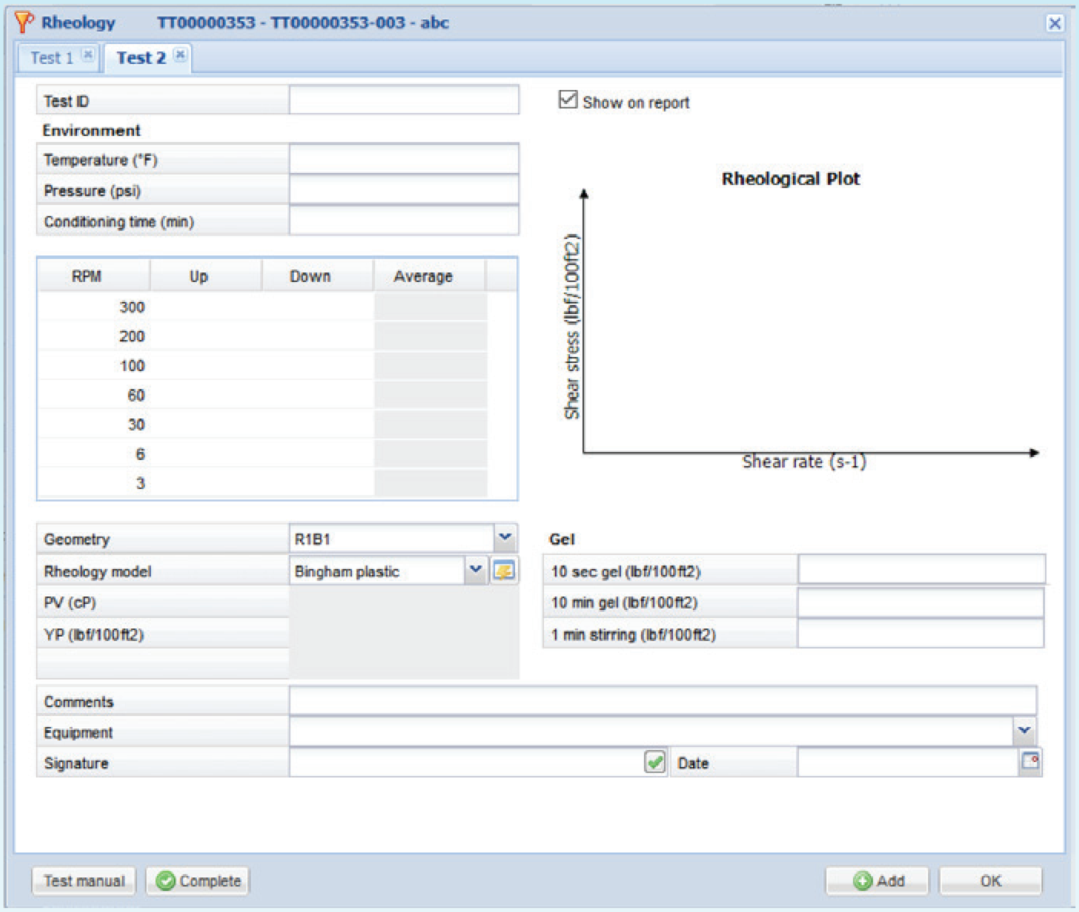


Fig. 6. Rheology Test

Compressive Strength test is another very important test that has to be done in the laboratory. On the Compressive Strength page, users are required to type the initial and final temperatures and pressures. (Fig. 7) There are two tables to fill in the test results: “Crush” and “UCA”. On the right side, there is a picture box where users can upload a picture generated by any testing device. All results and the picture will be printed to the final report. A snapshot of the Compressive Strength page is shown below.

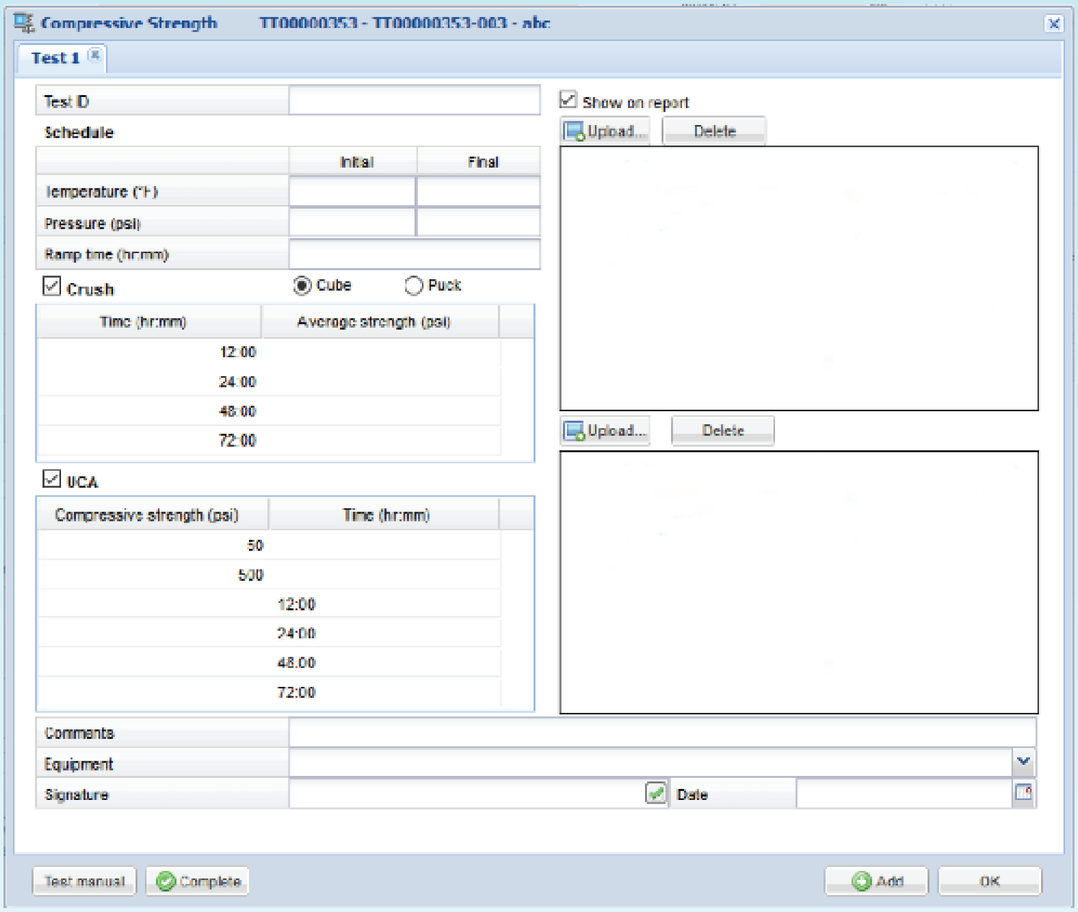


Fig. 7. Compressive Strength Test

6. Search

The general and advanced search functions enable users to find the formula and the previously done test in no time.

As for the search criteria, users can type in a key word in the field and search for one or multiple slurry designs. If users want to search by some numbers, such as a value for slurry density, then users can set a minimum and maximum limit. The system will search for all the slurry designs with a value in this given range. If only a minimum limit is given, the system will search all slurry designs with a value larger than this limit. Similarly, if only a maximum limit is given, the system will search all values below this limit. Users can also search by the code of a certain ingredient, such as “ClsA”. The system will search all slurry designs that contain ClsA cement. Users can search for a slurry design by providing some desired test results into an advanced search.

The more detailed search criterion, the more narrowed down the search results. (Fig. 8) For example, a user can search for all cement slurries designed for Eagleford Field Company within the past three months, with a slurry density between 12 to 13 ppg, and a well depth between 5000 to 6000 feet. Here is another example. If a user wants to know how a certain additive affects the slurry properties, then he can type in the additive code and search all slurries that contain this additive. For instance, if this user wants to find the hardest cement slurry, he can type in a number in the Strength field and search. CEMLab will show all slurries that have strengths higher than the number he entered.

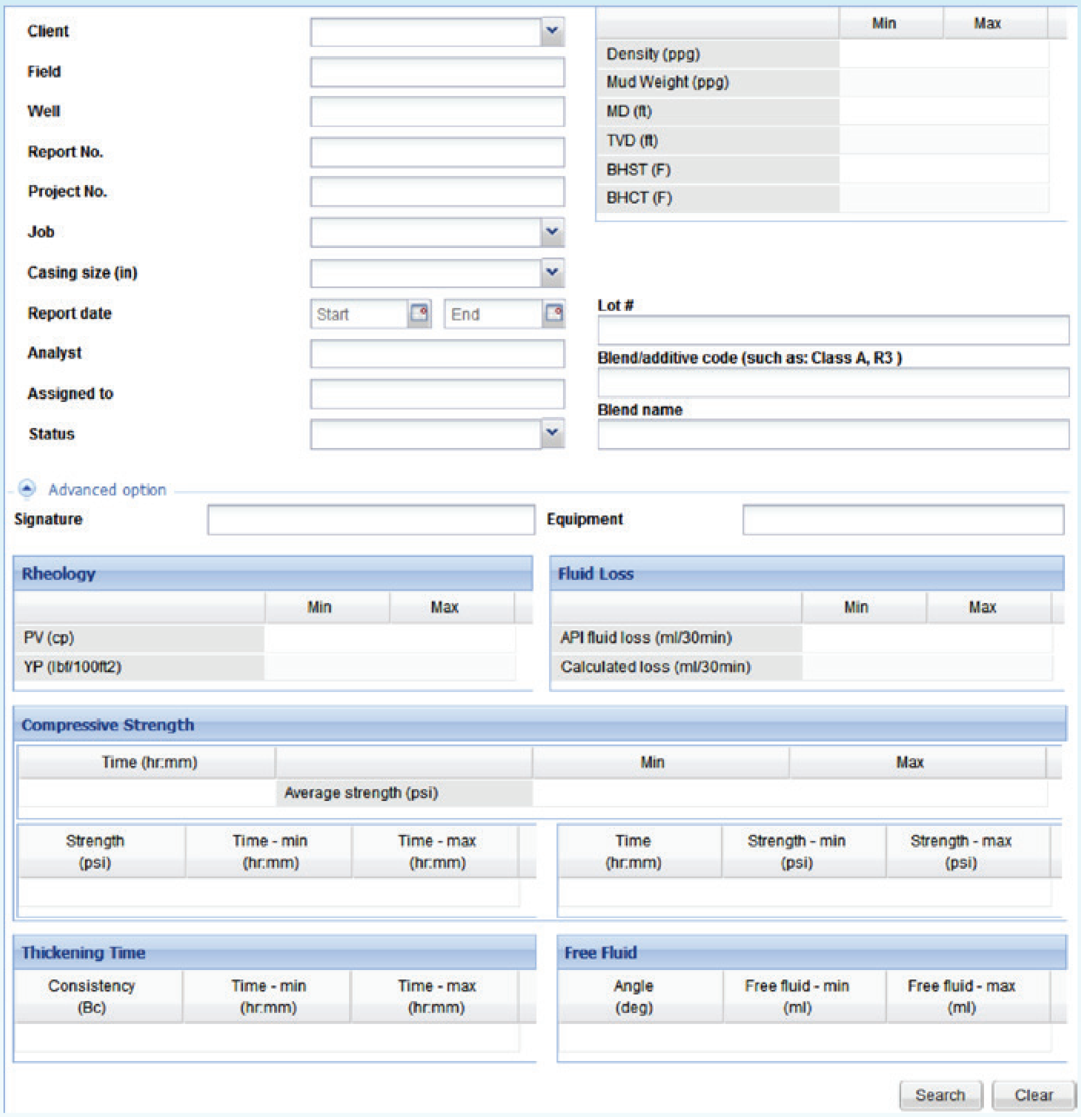


Fig. 8. Search Function

All slurries that meet the specified criteria are listed in the Search Results page. (Fig. 9) There may be so many results shown in this page that users still have difficulty locating the desired slurry. If this is the case, users can click on the column head to sort the column data from ascending to descending order, making it easier to find the desired slurry.

Search Results

#	Report No.	Client	Field	Well	Job	Casing size (in)	Density (ppg)	MD (ft)	TVD (ft)	BHST (F)	BHCT (F)	Formula	Analyst	Assigned tc	Status
1	TL00000001	BP	Eagle Ford	CD3-316B-5	Cementir	9 5/8	16	5000	4500	150	165	ClsA 100% + POZ75 15%	Bill Wang	Smith John	Returned
2	TL00000002	BP	Eagle Ford	CD3-316B-5	Cementir	9 5/8	18	5000	4500	150	165	ClsA 100% + POZ75 15%	Bill Wang	Bill Wang	Finalized
3	TL00000003	BP	Eagle Ford	CD3-316B-5	Cementir	9 5/8	14.8	5000	4500	150	165	ClsA 100% + POZ75 15%	Bill Wang	Peter Wong	Testing
4	TL00000004	BP	Eagle Ford	CD3-316B-5	Cementir	9 5/8	18	5000	4500	150	165	ClsA 100% + POZ75 15%	Bill Wang	N/A	Designing

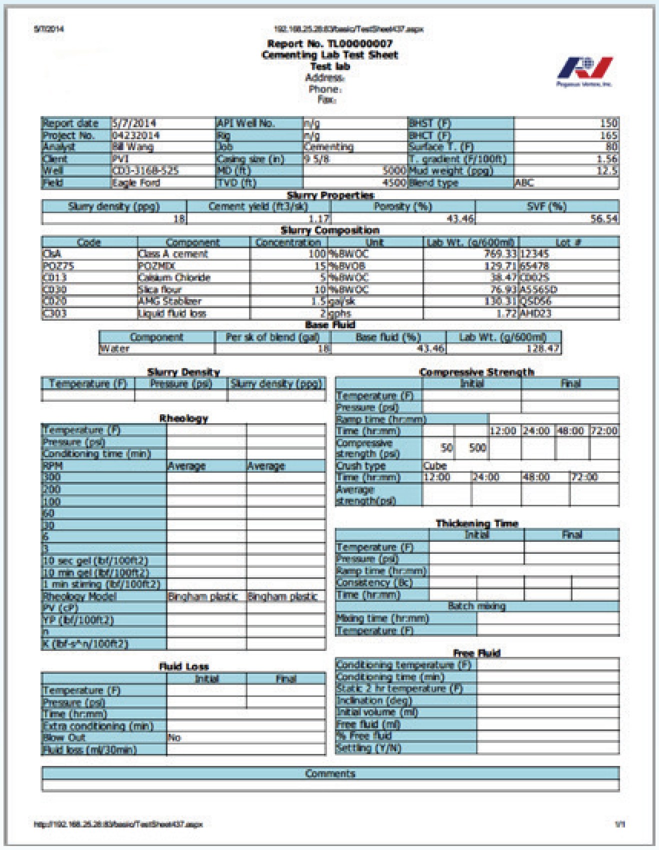
Page 1 of 1 Displaying reports 1 - 4 of 4

Fig. 9. Search Results

7. Reports

CEMLab can generate one test sheet and final report for each case. (Fig.10)

A test sheet has cement slurry formulas for lab technicians to use when mixing the slurries and blank tables to write the test results.



Report No. TL00000007
Cementing Lab Test Sheet
Test lab
Address:
Phone:
Fax:

Report date	5/7/2014	API Well No.	n/g	BHST (F)	150
Project No.	04232014	Rig	n/g	BHCT (F)	165
Analyst	Bill Wang	Job	Cementing	Surface T. (F)	80
Client	PVI	Casing size (in)	9 5/8	T. gradient (F/100ft)	1.56
Well	CD3-316B-525	MD (ft)	5000	Mud weight (ppg)	12.5
Field	Eagle Ford	TVD (ft)	4500	Blend type	ABC

Slurry Properties

Slurry density (ppg)	Cement yield (ft3/sk)	Porosity (%)	SVF (%)
18	1.17	43.46	56.54

Slurry Composition

Code	Component	Concentration	Unit	Lab Wt. (g/600ml)	Lot #
ClsA	Class A cement	100	%BWOC	769.33	12345
POZ75	POZMIX	15	%BVOB	129.71	65478
C013	Calcium Chloride	5	%BWOC	38.47	CD025
C030	Silica flour	10	%BWOC	76.93	AS565D
C020	AMG Stabilizer	1.5	gal/sk	130.31	QSD56
C303	Liquid fluid loss	2	gphs	1.72	AHD23

Base Fluid

Component	Per sk of blend (gal)	Base fluid (%)	Lab Wt. (g/600ml)
Water	18	43.46	128.47

Slurry Density

Temperature (F)	Pressure (psi)	Slurry density (ppg)

Compressive Strength

	Initial		Final			
Temperature (F)						
Pressure (psi)						
Ramp time (hr:mm)						
Time (hr:mm)			12:00	24:00	48:00	72:00
Compressive strength (psi)	50	500				
Crush type	Cube					
Time (hr:mm)	12:00	24:00	48:00	72:00		
Average strength(psi)						

Rheology

Temperature (F)		
Pressure (psi)		
Conditioning time (min)		
RPM	Average	Average
300		
200		
100		
60		
30		
6		
3		
10 sec gel (lbf/100ft2)		
10 min gel (lbf/100ft2)		
1 min stirring (lbf/100ft2)		
Rheology Model	Bingham plastic	Bingham plastic
PV (cP)		
YP (lbf/100ft2)		
n		
K (lbf-s^n/100ft2)		

Thickening Time

	Initial		Final	
Temperature (F)				
Pressure (psi)				
Ramp time (hr:mm)				
Consistency (Bc)				
Time (hr:mm)				
Batch mixing				
Mixing time (hr:mm)				
Temperature (F)				

Fluid Loss

	Initial	Final
Temperature (F)		
Pressure (psi)		
Time (hr:mm)		
Extra conditioning (min)		
Blow Out	No	
Fluid loss (ml/30min)		

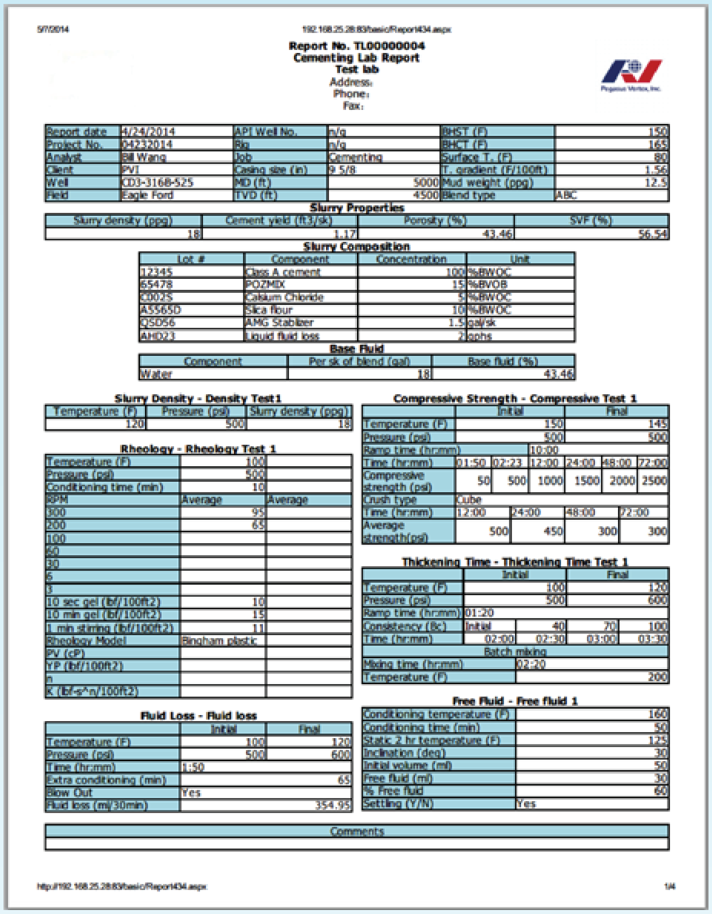
Free Fluid

Conditioning temperature (F)	
Conditioning time (min)	
Static 2 hr temperature (F)	
Inclination (deg)	
Initial volume (ml)	
Free fluid (ml)	
% Free fluid	
Settling (Y/N)	

Comments

Fig. 10. Test Sheet

The final report is a total summary of the slurry job. (Fig. 11) It contains the slurry formula, test results, some test graphs and the super sack sheet, if applicable.



5/7/2014 192.168.25.28:83/basic/Report434.aspx

Report No. TL00000004
Cementing Lab Report
Test lab
Address:
Phone:
Fax:

Report date	4/24/2014	API Well No.	n/a	BHST (F)	150
Project No.	04232014	Rig	n/a	BHCT (F)	165
Analyst	Bill Wang	Job	Cementing	Surface T. (F)	80
Client	PVI	Casing size (in)	9 5/8	T. gradient (F/100ft)	1.56
Well	CD3-316B-525	MD (ft)	5000	Mud weight (ppg)	12.5
Field	Eagle Ford	TVD (ft)	4500	Blend type	ABC

Slurry Properties

Slurry density (ppg)	Cement yield (ft3/sk)	Porosity (%)	SVF (%)
18	1.17	43.46	56.54

Slurry Composition

Lot #	Component	Concentration	Unit
12345	Class A cement	100	%BWOC
65478	POZMIX	15	%BVOB
C002S	Calcium Chloride	5	%BWOC
A5565D	Silica flour	10	%BWOC
QSD56	AMG Stabilizer	1.5	gal/sk
AHD23	Liquid fluid loss	2	gphs

Base Fluid

Component	Per sk of blend (gal)	Base fluid (%)
Water	18	43.46

Slurry Density - Density Test1

Temperature (F)	Pressure (psi)	Slurry density (ppg)
120	500	18

Rheology - Rheology Test 1

Temperature (F)	100	
Pressure (psi)	500	
Conditioning time (min)	10	
RPM	Average	Average
300	95	
200	65	
100		
60		
30		
6		
3		
10 sec gel (lbf/100ft2)	10	
10 min gel (lbf/100ft2)	15	
1 min stirring (lbf/100ft2)	11	
Rheology Model	Bingham plastic	
PV (cP)		
YP (lbf/100ft2)		
n		
K (lbf-s^n/100ft2)		

Fluid Loss - Fluid loss

	Initial	Final
Temperature (F)	100	120
Pressure (psi)	500	600
Time (hr:mm)	1:50	
Extra conditioning (min)	65	
Blow Out	Yes	
Fluid loss (ml/30min)	354.95	

Compressive Strength - Compressive Test 1

	Initial			Final		
Temperature (F)	150			145		
Pressure (psi)	500			500		
Ramp time (hr:mm)	10:00					
Time (hr:mm)	01:50	02:23	12:00	24:00	48:00	72:00
Compressive strength (psi)	50	500	1000	1500	2000	2500
Crush type	Cube					
Time (hr:mm)	12:00	24:00	48:00	72:00		
Average strength(psi)	500	450	300	300		

Thickening Time - Thickening Time Test 1

	Initial		Final	
Temperature (F)	100		120	
Pressure (psi)	500		600	
Ramp time (hr:mm)	01:20			
Consistency (Bc)	Initial	40	70	100
Time (hr:mm)	02:00	02:30	03:00	03:30
Batch mixing				
Mixing time (hr:mm)	02:20			
Temperature (F)	200			

Free Fluid - Free fluid 1

Conditioning temperature (F)	160
Conditioning time (min)	50
Static 2 hr temperature (F)	125
Inclination (deg)	30
Initial volume (ml)	50
Free fluid (ml)	30
% Free fluid	60
Settling (Y/N)	Yes

Comments

http://192.168.25.28:83/basic/Report434.aspx 1/4

Fig. 11. Final Report

III. Conclusion

As a result of working with cementing companies and operators, CEMLab is a platform to aid experts and technicians in creating globally consistent slurry/spacer formulations and to rapidly disseminate cementing techniques.

This advanced software solution incorporates a uniform design philosophy and a common historical support base for multiple cement labs worldwide.

For more information on CEMLab, please contact Pegasus Vertex, Inc. at:

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