Research and Workplace Innovation Program

Final Report

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WATSIN Chemical Exposure Algorithm

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Project Overview

Airborne exposure to chemicals is a major route of exposure in a workplace and can result in cancer, respiratory effects and central nervous system effects. Manitoba legislation requires employers to assess potential chemical exposures. And every workplace has numerous Safety Data Sheets (SDSs) but no practical way to use them to predict worker exposure. Sampling worker exposure can be a significant cost to a company. Airborne worker exposure assessments are especially challenging for small manufacturers that have limited resources and knowledge.

The most common approach to assessing chemical exposures is by subjective assessment. The American Industrial Hygiene Association says that “subjective assessment of exposures tend to be inaccurate and inconsistent with the exception of extreme scenarios. In fact, research has shown subjective qualitative exposure judgements tend to be no more accurate than random chance with a significant underestimation bias thus increasing the risk to workers”.

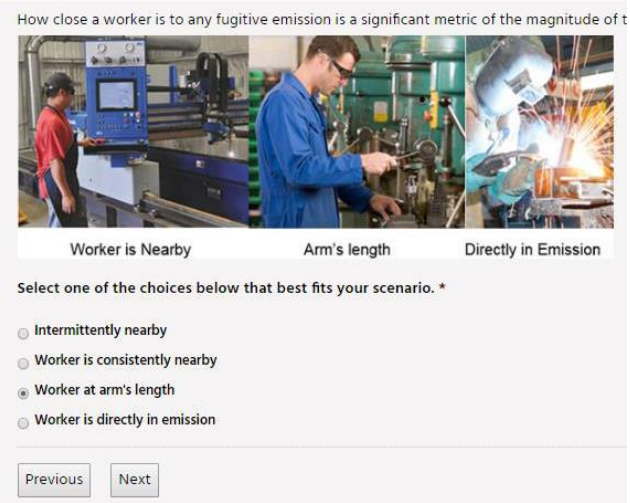
AIHA: A strategy for Assessing and Managing Occupational Exposures

The RWIP grant had two main goals. Firstly, to test the accuracy of a web-based algorithm called WATSIN. As a tool, it predicts worker exposures to chemicals by comparing the algorithm’s predictions to measured airborne concentrations. The porject was to predict the exposures of 200 workers and then compare those predictions to the actual measured exposure of those workers. In this manner, the statistical accuracy of the algorithm could be determined.

The second objective was to make WATSIN available to Manitoba workplaces to allow them to self-assess various exposure scenarios in their workplace using WATSIN.

Introduction to WATSIN

WATSIN walks the user through 6 questions to define the conditions that contribute to worker exposure. WATSIN considers factors such as duration of the process, the nature of the process, worker proximity to the process, the Occupational Exposure Limit, any respiratory protection used, and ventilation controls in building. Each question has a short list of options in which to describe their situation at a particular workstation. An example is shown below.



Option List for Worker Position

User simply clicks on the description of worker position that best describes the scenario they are investigating and click Next to go to the next question.

WATSIN actually consists of two similar versions: One for dusts and one for liquids.

Dust Version – used to assess airborne particulates from sawing, grinding, welding and so on; and

Liquids Version- used to assess products that evaporate such as paints and solvents.

Both systems are easy to use and several of the questions are common to both of the versions (e.g., duration of use, worker position).

Once the information on the process is entered, the WATSIN program will generate a prediction of that worker's exposure. The results are expressed as a percent of the Occupational Exposure Limit (OEL) within exposure bands. This provides a quick and easy assessment of airborne worker

exposure and allowed companies to assess chemicals proactively and explore substitution of safer chemicals. In addition, the process is confidential as the entries are anonymous.

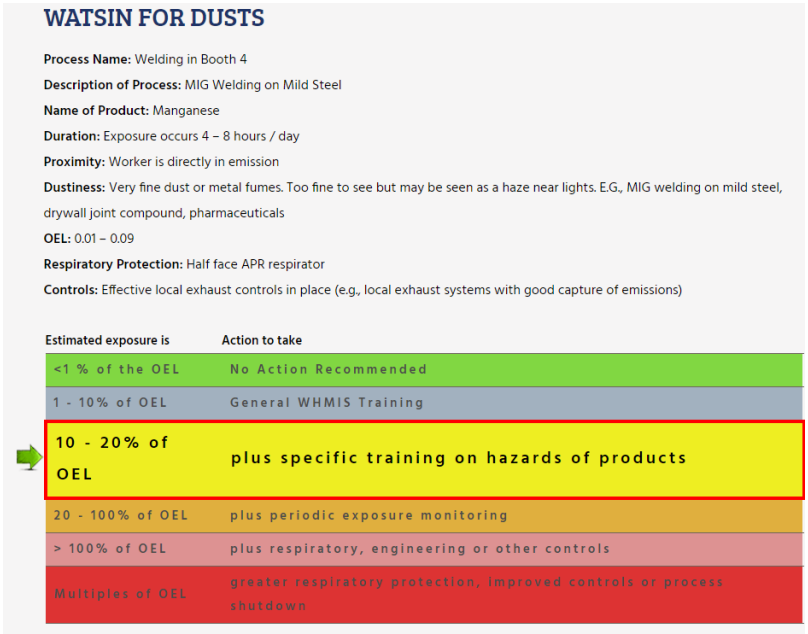
Each exposure band comes with recommendations for follow up or action. If the predicted exposure is very low, no action is recommended. If the predicted exposure is at a level of concern, the appropriate action is recommended. The recommendations are shown in the table below.

Exposure Bands

Exposure Rating	Recommended Action / Follow Up
< 1% of OEL	No Action
1 - 10% of OEL	General WHMIS Training
10 - 20% of OEL	+ Specific training on hazards of product
20 - 100% of OEL	+ periodic exposure monitoring
> 100% of OEL	+ respiratory, engineering or other controls
multiples of OEL	greater respiratory protection or process shutdown, introduce improved engineering controls

A WATSIN exposure prediction displays the name and description of the process, the assumptions entered into the algorithm by the company, the predicted exposure band and the appropriate action to take (based on the prediction). Below is an example of a WATSIN prediction. This example is for a worker who is MIG welding on mild steel with a half face respirator and effective local exhaust ventilation.

Example of the WATSIN Prediction Printout



WATSIN FOR DUSTS

Process Name: Welding in Booth 4
Description of Process: MIG Welding on Mild Steel
Name of Product: Manganese
Duration: Exposure occurs 4 – 8 hours / day
Proximity: Worker is directly in emission
Dustiness: Very fine dust or metal fumes. Too fine to see but may be seen as a haze near lights. E.G., MIG welding on mild steel, drywall joint compound, pharmaceuticals
OEL: 0.01 – 0.09
Respiratory Protection: Half face APR respirator
Controls: Effective local exhaust controls in place (e.g., local exhaust systems with good capture of emissions)

Estimated exposure is	Action to take
<1 % of the OEL	No Action Recommended
1 - 10% of OEL	General WHMIS Training
10 - 20% of OEL	plus specific training on hazards of products
20 - 100% of OEL	plus periodic exposure monitoring
> 100% of OEL	plus respiratory, engineering or other controls
Multiples of OEL	greater respiratory protection, improved controls or process shutdown

In this example, WATSIN predicts an exposure between 10% and 20% of the OEL. That is to say that WATSIN predicts that if air samples were taken to measure that worker's exposure, the results of the testing would show an exposure between 10% and 20% of the OEL

WATSIN can also be used to predict current exposures or exposures for new products or processes that are to be introduced to a workplace. A company can enter the details of the process and determine if the process produces an acceptable exposure with no controls or the planned controls. If the predicted exposure is unacceptable, the user can than alter the prediction to include better control – such as local exhaust ventilation - and get a revised prediction for the exposure as if the process used local exhaust ventilation. In this manner, processes can be introduced in a workplace with the necessary controls.

In a similar manner, WATSIN can be used to explore how an exposure would change if a different chemical was used (substitution). For example, a prediction could be done on a cleaning process using toluene. Then the same process could be assessed again with the same conditions but using xylene instead of toluene. This would can help companies quickly and easily select safer chemicals. It can also help companies save money by selecting chemicals that would not need respiratory protection or expensive exhaust systems.

The model was created to be easy to use by individuals with no formal training in industrial hygiene or knowledge of chemistry. Efforts have been made to make the program as easy to use as possible. For example, the Vapour Hazard Ratio (VHR) is an excellent metric to predict potential exposures to liquids. The VHR combines both the occupational exposure limit and the physical volatility of the product. The higher the VHR, the more likely the use of a product results in an exposure above the OEL. The VHR is a term/concept that is not known to many people, so the program has a database of VHRs of common chemicals that the user can search to quickly obtain the VHR of a chemical. The database contains the VHR for over 100 common chemicals plus an additional tool to calculate the VHR for a product not already in the database.

Image of Searchable Table of VHR (ranked in Descending Order)

Search:

CAS #	Name	TLV (ppm)	VHR
106-94-5	1-Bromopropane	0.1	1460000
75-15-0	Carbon disulfide	1	472000
71-43-2	Benzene	0.5	249000
56-23-5	Carbon tetrachloride	5	30300
67-66-3	Chloroform	10	25900
50-00-0	formaldehyde	0.1	17105

Workplace Measurements of Predicted Exposures

The grant planned to compare 200 workers – prediction of exposure (utilizing WATSIN) and then actual on-site testing (under real life conditions). Half of the 200 comparative assessments were funded under the grant. The other half of the 200 desired comparative assessments were provided by Winnipeg Air Testing. Winnipeg Air Testing is an industrial hygiene consulting company and performs worker exposure monitoring across Manitoba for a wide range of metals, dusts and chemicals.

The occupational exposure of each of these workers was predicted using the WATSIN algorithm. Next, on-site worker exposure testing was performed. The worker's actual exposure was measured by collecting air samples and sending the samples to an accredited laboratory. Based on the laboratory results, the actual measured worker exposure was then compared to the predicted exposure. This allowed a comparison between actual and predicted exposures. It is important to note that the predicted exposure was recorded before the air samples were collected or the laboratory results were available.

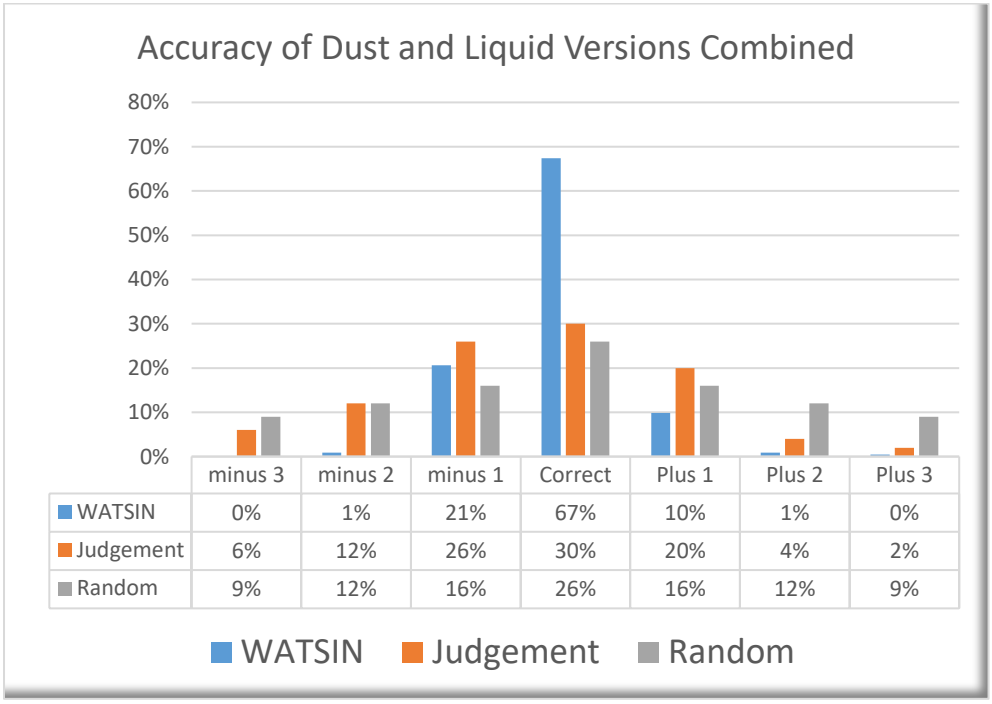
Testing under the grant was performed at 25 companies and resulted in the collection of 102 data points. Six of the surveys were performed outside of Winnipeg including: Morden, Winkler, Altona, Steinbach and 2 smaller rural communities. The testing included a wide number of different chemicals and processes. Data provided by Winnipeg Air Testing added an additional 131 data points, bringing the total number of data points to 233. The table below shows an example of how the predicted exposure and the measured exposure of the first 4 samples collected under the grant were prepared.

Predicted Exposures Vs Measured Exposures by Process

Process	Estimated Exposure	Lab Result	Comment
01 - Solder with Zinc-based Solder	<1% of OEL	0.7% of OEL	-
02 and 03 - Grinding of Metals	<1% of OEL	2% of OEL	Average of 2 samples
04 - Grinding of Fibreglass in Booth	1 – 10%	4% of OEL	-

Accuracy of WATSIN Predictions

As mentioned earlier, the study compared the predicted worker exposure (in bands) the actual measured worker exposure. The 233 results are summarized in the following graph that shows the distribution of predicted exposures compared to actual measured exposures in exposure bands.



	minus 3	minus 2	minus 1	Correct	Plus 1	Plus 2	Plus 3
WATSIN	0%	1%	21%	67%	10%	1%	0%
Judgement	6%	12%	26%	30%	20%	4%	2%
Random	9%	12%	16%	26%	16%	12%	9%

The WATSIN algorithm picked the correct band 67% of the time. The graph compares the accuracy of predicting the correct exposure band to both professional judgement of Industrial Hygienists and random chance. These last two values were taken from an AIHA Exposure Assessment Course.

A correct prediction rate of 67% is a score 41% higher than random chance which picks the correct exposure band 26% of the time. It should be noted that Industrial Hygienists using professional judgement predict the correct exposure band only 4% more than random chance.

It is clear that the WATSIN algorithm is a useful tool to assess potential worker exposures and is significantly better at predicting the correct exposure band than professional judgement. Simply put, the WATSIN algorithm allows the layperson to better assess chemical exposures than an experienced Industrial Hygienist.

The following terminology was used to assess and interpret the accuracy of a prediction model:

Accuracy of Prediction	Term
Predicted Band = Measured Band	Hit
Out by One Band (high or low)	Acceptable
Out by Two Bands	Miss
Out by Three Bands.	Unacceptable

For example, for the results shown below, two of the predictions would be “hits” because the lab results came back in the same exposure band as the predicted exposure. The grinding of metals prediction would be deemed to be acceptable because it is only out by one exposure band from the correct exposure band. Specifically, it predicted an exposure less than 1% of the OEL whereas the two measured exposures averaged 2% of the OEL.

Process	Estimated Exposure	Measured Exposure	Comment
01 – Solder with Zinc-based Solder	<1% of OEL	0.7% of OEL	Hit
02 and 03 Grinding of Metals	<1% of OEL	2% of OEL	Acceptable
04 – Grinding in Fibreglass Booth	1 – 10% of OEL	4% of OEL	Hit

Based on the entire set of data, the WATSIN algorithm (combining both the dust and liquid data) provides an “acceptable” prediction 98% of the time. That is to say that it predicts the correct exposure band or is within one exposure band of the measured exposure 98% of the time. Professional judgement shows an “acceptable” prediction 76% of the time.

WATSIN had a “miss” or “unacceptable prediction (i.e., out by two or more exposure bands) 2% of the time, whereas professional judgement has a miss or unacceptable prediction 24% of the time.

The study concludes that the WATSIN algorithm is a reasonable tool to assess workers’ exposure to chemicals and is statistically more accurate than professional judgement by an Industrial Hygienist.

Use of WATSIN by Manitoba Workplaces

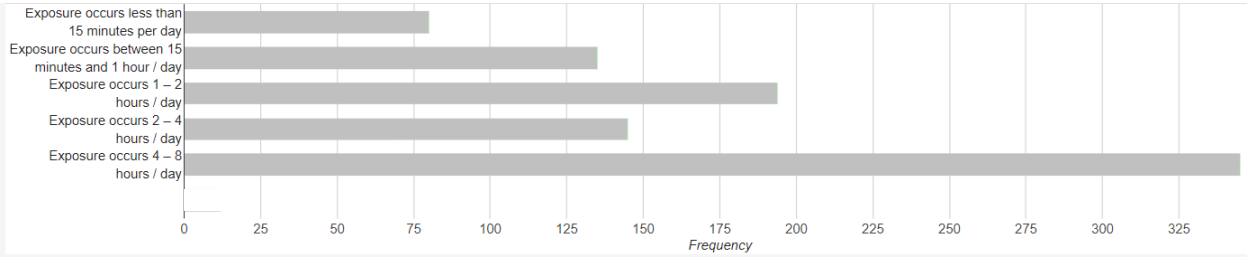
During the grant, Manitoba workplaces had free access to WATSIN and were encouraged to use WATSIN so that they could perform exposure assessments themselves. Presentations were made to professional organizations and safety partners in Manitoba to introduce WATSIN and explain how to use it. A total of 189 companies signed up to access WATSIN. These companies collectively performed 1,536 chemical assessments. This included 912 exposure predictions using the Liquids version of WATSIN and 624 exposure predictions using the Dusts version of WATSIN.

Each user averaged about 8 scenarios each. This would be a reasonable number to assess the potential exposures of primary activities within a moderate sized workplace. Looking at the average number of assessments per company over the span of the grant, the average number of chemical assessments has increased from 7 per user to 8 per user. This small increase may suggest that “earlier” users are sometimes going back to WATSIN to access an additional or changed processes within their workplace (e.g., evaluating the potential of a new chemical being used, exploring safer chemicals through substitution, the effect that improved controls would have in reducing exposure, etc.).

WATSIN Records the Assumptions Entered by the User

When using WATSIN, the user enters the parameters of the exposure scenario such as exposure duration, type of respirator worn, etc. The program records the details of each assessment and provides a breakdown of how often each option is selected. The example below shows the distribution of responses based on time duration.

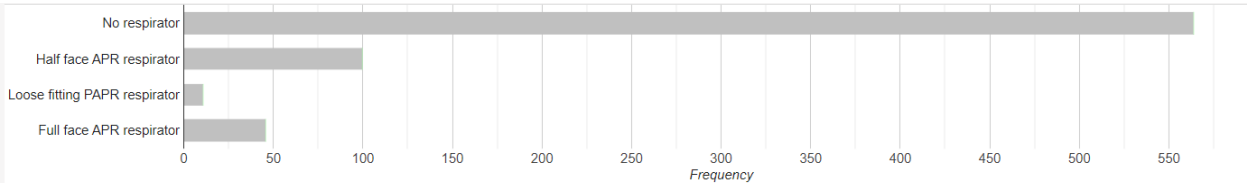
Distribution of Duration of Exposure - Taken from Liquids Version of WATSIN



A duration of 4 – 8 Hour time assessments was the most common assumption in an exposure scenario.

Other conditions of the exposure scenarios entered into WATSIN are also recorded by the database. For example, very few of the Liquids version exposure scenarios had workers wearing respirators. 63% of the scenarios for liquids reported no respiratory protection. Dusts scenarios had a very similar result by entering “no respirator” 59% of the time. In fact, the most common type of “control” was moderate general ventilation.

Respirator Usage from Liquids Version



Project Summary

- The ability to assess hazards in the workplace like exposures to chemicals and dusts is a key aspect of a safety and health program.

- The WATSIN chemical exposure algorithm is an easy-to-use tool that the layperson can use to predict occupational exposures to dusts and chemicals from industrial processes. WATSIN provides statistically-proven accuracy and is more accurate than professional judgement by an Industrial Hygienist at predicting chemical exposures.

- During the timeline of the grant, Manitoba workplaces used WATSIN to assess over 1,500 chemical exposures. In so doing, these companies likely self-identified hundreds of significant exposures in their workplace. This identification of significant exposure is the first step and arguably the hardest step to addressing unsafe exposures in the workplace.

- It is estimated that there are 4,000 – 5,000 companies that have significant chemical exposures in Manitoba. To date, the market penetration of WATSIN is mainly been medium and large companies. There appears to be very few small companies as users, despite

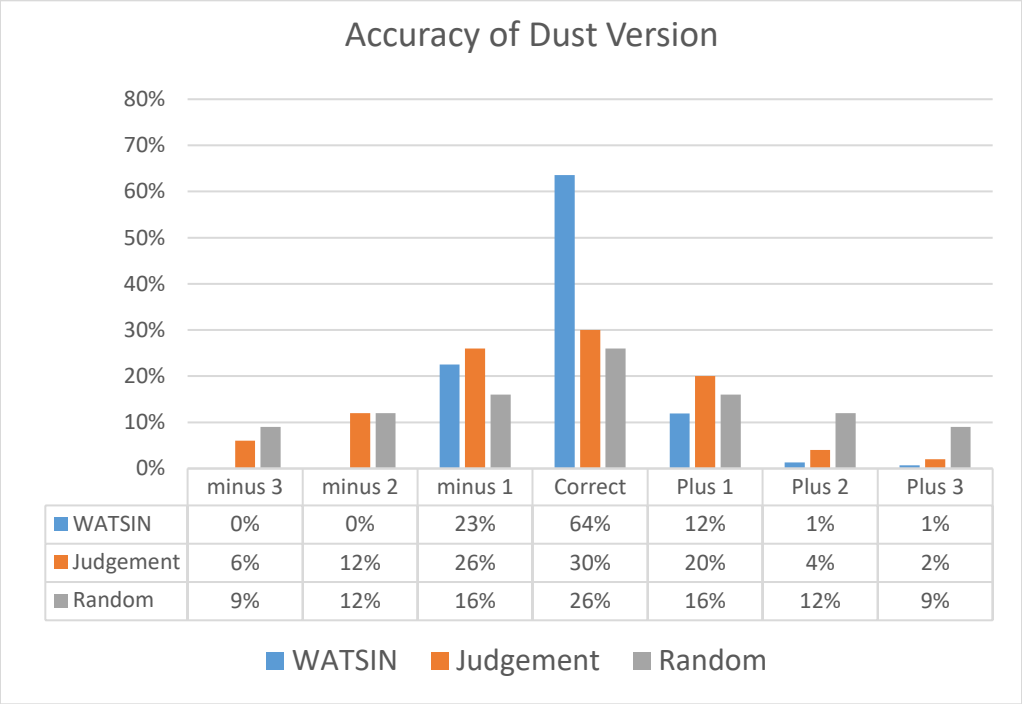
making up the largest proportion of workplaces in the province. These smaller companies typically have less established safety programs and less safety and health resources, yet the exposure hazard(s) are the same.

- Workplaces should be encouraged to use WATSIN in assessing chemical exposures in their workplace. WATSIN is also an effective tool for government inspectors and Industrial Hygienists. The use of the same tool in both groups would provide a seamless approach to assessing chemical exposures in Manitoba workplaces.

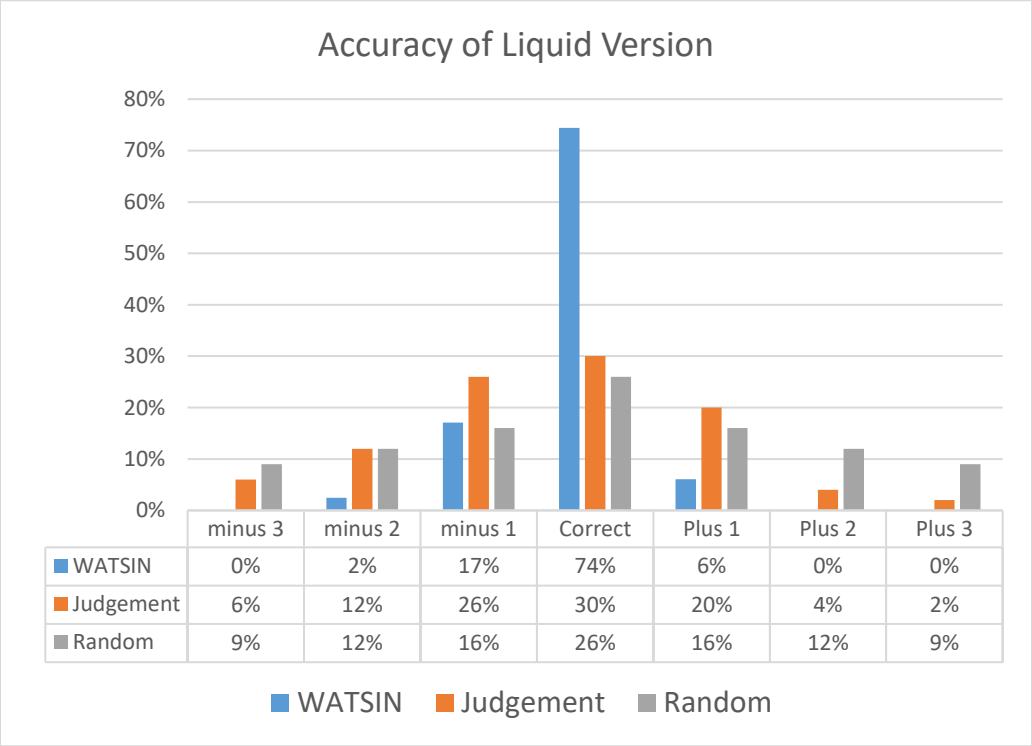
Respectfully Submitted,

Douglas N. Wylie, CIH, ROH, CRSP, CRM

Appendix I – Accuracy of Separate Dust and Liquid Versions of WATSIN



	minus 3	minus 2	minus 1	Correct	Plus 1	Plus 2	Plus 3
WATSIN	0%	0%	23%	64%	12%	1%	1%
Judgement	6%	12%	26%	30%	20%	4%	2%
Random	9%	12%	16%	26%	16%	12%	9%



	minus 3	minus 2	minus 1	Correct	Plus 1	Plus 2	Plus 3
WATSIN	0%	2%	17%	74%	6%	0%	0%
Judgement	6%	12%	26%	30%	20%	4%	2%
Random	9%	12%	16%	26%	16%	12%	9%