

Valley Children's Laboratory: An Auto-verification Journey

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Valley Children's Hospital



- 330 beds at main hospital
- Multiple Outpatient Clinics on campus
- Laboratory
 - ~250-350 Chemistry specimens/day
 - ~200-250 Hematology specimens/day
 - ~50 Coagulation specimens/day
 - ~80-120 Urinalysis specimens/day

Core Laboratory Instruments



- **Chemistry**
 - Abbott Architect c4000
 - Abbott Architect ci4100
- **Hematology**
 - Beckman Coulter DxH 1601 (2 analyzers plus SMS)
 - Cellavision DM96
 - iQ200 Select (Body Fluids)
- **Coagulation**
 - Stago Compact (2 analyzers)
 - Rotem Delta
- **Urinalysis**
 - Arkray Aution Hybrid 4050
 - Siemens Clinitek Status+

Laboratory Software



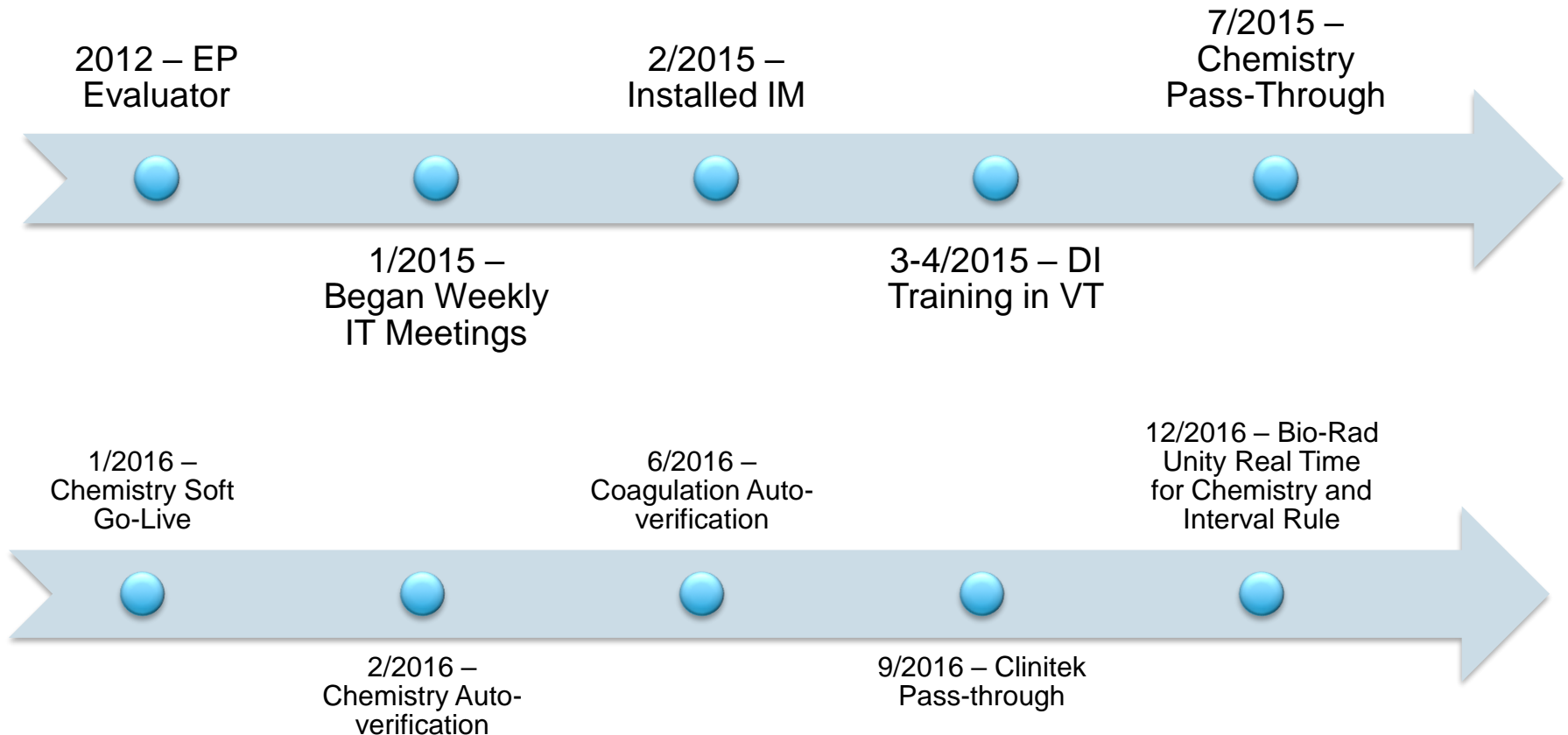
- LIS: Meditech Client Server 5.67
- Instrument Manager v8.16 (upgraded from v8.13 on 8/2018)
 - IM LIVE
 - 17 Connections
 - 8 Thin Client Licenses
 - Specimen Management
 - IM TEST
 - 5 Connections
 - 3 Thin Client Licenses
 - IM MIRROR
- Bio-Rad Unity Real Time

Initiating Steps



- LEAN project
 - TAT monitoring
 - Auto Cell / Manual Cell
 - Establish procedures for new workflow
 - Identified need for Auto-verification to improve efficiency
- Coordinated purchase of new Chemistry analyzers with IM as the interface
 - Had the option to purchase middleware through Abbott
 - Would have been more difficult to apply AV to the rest of the lab because they are not all on the Abbott platform without purchasing additional software had we went this route
 - IM provided the most versatile solution

2015-2016 Implementation Milestones



2017-2018 Implementation Milestones



2/2017 – UA Auto-
verification
(including Clinitek)

7/2017 – iQ200
Pass-through

6/2017 – Rotem
Pass-through

11/2017 –
Hematology Pass-
through

2/2018 –
Hematology
Auto-
verification

7/2018 – Bio-
Rad Unity for
Hematology

TBD/2018 –
Laboratory
Intelligence

3/2018 – Bio-
Rad Unity for
Coagulation

8/2018 –
Upgraded IM
from v8.13 to
v8.16

Average Turn-Around-Times (in minutes) Received in Lab to Verify



Department	2015	2018	Delta	Auto-verification Rates
Chemistry	34	27	↓ 7	~93%
Coagulation	29	21	↓ 8	~91%
Urinalysis	22	15	↓ 7	~51%
Hematology (Hemogram)	19	10	↓ 9	~78%

Areas for future improvement of TAT and Auto-verification rates:

- Delta Checks for Hematology
- Re-evaluate Instrument errors for relevance
- Re-evaluate current hold rules for efficiency and effectiveness

Factors in Successful Implementation of IM



1. Dedicated Resource (Middleware Coordinator)
2. Dedicated DI Consultant (Brandon Robison)
3. Implementation team - consisted of a good working relationship with IT and Laboratory Technical Specialists
4. Weekly project update meetings held with Medical Director, Lab Administrative Director, Lab Operations Manager
5. Constant communication and collaboration with core lab CLS

Future Goals



- On-going modification and validation of Rules
- Regular driver and software upgrades
- Implement Laboratory Intelligence
- Transition to EPIC
- Possibly implement CAP and EP Evaluator interfacing
- Evaluation for possible movement into other areas of the Laboratory (Molecular Pathology and Microbiology)

Connections, Workspaces, and Rules examples



System Configuration Diagnostics Security Specimen Management SSR DC SR MM MA Laboratory Intelligence Reports Window Help

Start Selected Connections Stop Selected Connections Resend Messages Clear SendQ Mark Out-of-Service Log Minimal SEL Events Utility

Enter Find Text

Connection	Status	Communi...	In Service	In	InQ	SendQ	Sent	Errors	Driver Na...	Driver Version
System										
Archive	On	Off				0	28	0	imarchive	
Purge	On	Off						0	imp	
Qmgr	On (2/2)	Off				0	4	0	im	v8.16.00.19
Quality Control	On	Off						0	imqc	
Specimen Routing	On	Off						0	imSpecR...	
User Defined										
ARCHITECT c4000	Off	Off	Yes	0	0	0	0	0	abdarchi	v8.00.0034
ARCHITECT ci4100	Off	Off	Yes	0	0	1	0	0	abdarchi	v8.00.0034
ARKRAY CHM	Off	Off	Yes	0	0	0	0	0	ark4030i	v8.00.0004
ARKRAY FCM	Off	Off	Yes	0	0	0	0	0	sysuf1ki	v8.00.0007
BioRad QC Connectivity	Utility	Off	Yes	0	0	0	0	0	brlqccnq	v8.07.0005
CELLAVISION	Off	Off	Yes	0	0	0	0	0	cvndm96i	v8.00.0016
CLINITEK	Off	Off	Yes	0	0	0	0	0	smscsc7i	v8.00.0004
DxH	Off	Off	Yes	0	0	0	0	0	bkmdxh8i	v8.00.0025
iQ200	Off	Off	Yes	0	0	0	0	0	iriq200i	v8.00.0018
ORDERS ROBODIDN	On	Off	Yes	0	0	0	0	0	diicastl	v8.00.0024
PRINTER	On	Off	Yes	0	0	0	0	0	diirprt	v8.00.0027
RESULTS ROBODIUP	On	Off	Yes	0	0	0	2	0	diicastl	v8.00.0024
ROTEM ORDERS	Off	Off	Yes	0	0	0	0	0	rotdelta	v8.00.0004
ROTEM RESULTS	Off	Off	Yes	0	0	0	0	0	rotdelta	v8.00.0004
STAGO 1	Off	Off	Yes	0	0	0	0	0	abpastai	v8.00.0024
STAGO 2	Off	Off	Yes	0	0	0	0	0	abpastai	v8.00.0024
Errors										
Last Date/Time	Qty	Error								

- Note that some analyzers/LIS may require 2 IM Connections
- Printer requires a connection

Chemistry Workspace



System Configuration Diagnostics Security Specimen Management SSR DC SR MM MA Laboratory Intelligence Reports Window Help

Workspace Edit View Format Action Help

Specimen ID Patient ID Patient Name CHEMISTRY 60

Specimen Worksheet

Specim...	Patient Name
[-] Tests Held	
032189	TEST,AMBULANCE
032190	TEST,ANDREW
[-] Pending	
032044	TEST,MARK
032046	TEST,ONE
[-] Complete	
032282	CABO,LUIS
032281	BEAR,TEDDY
032271	BEAR,TEDDY
032274	CABO,LUIS
032269	BEAR,TEDDY
032272	BEAR,TEDDY
032273	DAY1,PYXSISES01
032270	BEAR,TEDDY
032134	TEST,ADMIT

Patient Information

Patient Name: TEST,CREEK Patient ID: M000000356 Account Number: H00000020727
Location - Facility: CAC Phone: Instrument ID: C4
Location - Room: Rack: H756
Ordering Physician: Position: 3
Specimen Received Date/Time: 8/7/2018 10:53:00 AM Last Result to IM Date/Time: 8/7/2018 10:53:00 AM

Specimen ID: 032175 Date of Birth: Patient Age: Sex: M
Specimen Comment(s):
Query:

Test Worksheet

Test Name	Result	Flag	Units	Ref...	Error Name(s)	Test Comment(s)	Test Dilution	Rerun	Pr
* Released									
CSI-HEMOLYSIS	3+		Index				STANDARD	<input type="checkbox"/>	
POTASSIUM	7.1	*H	mmol/L		QC was not run within the appropriate time interval...	Critical result(s)	STANDARD	<input type="checkbox"/>	

- Utilize rules that work in conjunction with Bio-Rad Unity to hold QC failures
- Utilize rules that hold if an acceptable QC specimen was not run in the specified time interval from the last QC run
- Reruns can be ordered from the workspace
- TSH reflex to FT4 testing

Coagulation Workspace



System: Configuration Diagnostics Security Specimen Management SSR DC SR MM MA Laboratory Intelligence Reports Window Help

Workspace Edit View Format Action Help

Specimen ID: Patient ID: Patient Name: COAGULATION 60

Specimen Worksheet

Specimen...	Patient Name
- Pending	
032045	TEST, RAYMOND
032114	TEST, SUMO
- Complete	
032294	Fieldtag, test
032291	JANUARY, TESTING
032295	RAIN, TEST
032276	DOE, JOHN
032255	LABACK, TEST
032254	TEST, ACCOUNT
032296	KNOWN, NAME
032292	PHA, TRAIN
032257	BBK, LAB1
032256	TEST, ADM
240665	BRABBIN, JOSEPH L
240665	BRABBIN, JOSEPH L
240665	BRABBIN, JOSEPH L
240665	BRABBIN, JOSEPH L
254764	DIAZAYALA, DARWIN
254764	DIAZAYALA, DARWIN
254764	DIAZAYALA, DARWIN
254764	DIAZAYALA, DARWIN
032227	TEST, JANE

Patient Information

Patient Name: DOE, JOHN Patient ID: M000001838 Account Number: H00000

Location - Facility: DSG Phone: 35383 Instrument ID: STAC

Location - Room: Rack:

Ordering Physician: 8884815, LILLY ENDO STUDY,, Position:

Collection Date/Time: 8/13/2018 10:05:00 AM Specimen Received Date/Time:

Specimen Comment(s): @ Previously cancelled by AutoCancel on 08/15/18 at 0002.~@ Uncancelled by GLC on 08/15/18 at 0918. Last Result to IM Date/Time:

Sex: M Query:

Test Worksheet

Test Name	Result	Flag	Units	Reference R...	Error Name(s)	Test Comment(s)	Test Dilution	Rerun	Previ...	Previo...
* Released										
PROTIME	> 120.0	H	sec.	12.0 - 14.6	> Tmax, Result above lin...			<input type="checkbox"/>		
INR	NP		INR	0.8 - 1.4	> Tmax, Result above lin...			<input type="checkbox"/>		
PTT	> 200	*H	sec.	25.0 - 37.0	> Tmax, Result above lin...	Critical result(s)		<input type="checkbox"/>		
FIBRINOGEN	< 60	L	mg/dl	233.0 - 456.0	> Tmax, Result below lin...			<input type="checkbox"/>		

- Use of color coding for Critical Results and Specimen Department
- Rules are utilized to format results that fall outside of linear range.
- Factor rules to select correct result to report based on dilution factor

Test Worksheet

Test Name	Result	Flag	Units	Reference R...	Error Name(s)	Test Comment(s)	Test
* Released							
F8 ACT	110			58 - 170	Check result that the cor...		
F8A 1:10	> 120		%	58 - 170	Check Precision., Result ...		
F8A 1:20	110		%	58 - 170	Check Precision.		
F8A 1:40	105		%	58 - 170	Check Precision.		

Urinalysis Workspace



System Configuration Diagnostics Security Specimen Management SSR DC SR MM MA Laboratory Intelligence Reports Window Help

Workspace Edit View Format Action Help

Specimen ID: [] Patient ID: [] Patient Name: [] URINALYSIS

Specimen Worksheet

Specimen ID	Patient Name	P...
Pending		
032101	TEST,ADM	R
Complete		
032264	Rachael,Test	R
032248	CALAMITY,GANON	R
032247	UMTESTNEWGOV,HN3...	R
032246	ADM,TEST	R
032245	ADM,TEST	R
032244	BABYOO,MELANIE	R
032262	TEST,BROOKE	R
032249	TEST,ANDREW	R
032250	TEST,ADMIT	R
032251	TEST,AMBULANCE	R
032252	TEST,ANDY	R
032253	TEST,BABY	R

Patient Information

Patient Name: TEST,ANDY Patient ID: M000001521 Account Number: H000000313
 Specimen ID: 032252 Location - Facility: CMCC Phone: 36425 Instrument ID: ARK
 Date of Birth: 1/1/2010 Location - Room: Rack: 1
 Patient Age: 8 Y Ordering Physician: HORSJ,HORSPPOOL,JAMES C DO, Position: 4
 Sex: M Collection Date/Time: 8/12/2018 12:00:00 AM
 Specimen Received Date/Time: 8/12/2018 10:56:00 AM Last Result to IM Date/Time: 8/12/2018 10:56:00 AM

Specimen Comment(s):
 Query: Source: Clean Catch

Test Worksheet

Test Name	Result	Flag	Units	Reference R...	Error Name(s)	Test Comment(s)	Rerun	Test Instr...
Released								
Color	YELLOW			- Colorless			<input type="checkbox"/>	ARK
Clarity	Hazy	H		- Clear			<input type="checkbox"/>	ARK
Specific Gravity	1.024			1.003 - 1.035			<input type="checkbox"/>	ARK
Leukocyte	3+	H	Leu/uL	- Negative			<input type="checkbox"/>	ARK
Nitrite	Positive	H		- Negative			<input type="checkbox"/>	ARK
pH	6.0			5 - 8			<input type="checkbox"/>	ARK
Protein	70	H	mg/dL	- Negative			<input type="checkbox"/>	ARK
Glucose	Negative		mg/dL	- Negative			<input type="checkbox"/>	ARK
Ketone	100	H	mg/dL	- Negative			<input type="checkbox"/>	ARK
Urobilinogen	0.2		mg/dL	0.2 - 1			<input type="checkbox"/>	ARK
Bilirubin	Negative		mg/dL	- Negative			<input type="checkbox"/>	ARK
Blood, Urine	2+	H	mg/dL	- Negative			<input type="checkbox"/>	ARK
Urine WBC	999	H	/uL	0 - 28	Crosscheck WBC vs. LEUK		<input type="checkbox"/>	ARK
Urine RBC	41	H	/uL	0 - 22	!, PERFORM MICRO. Unable to differentiat...		<input type="checkbox"/>	ARK
Urine CASTS	> 30	H	/uL	0 - 4	PERFORM MICRO. Path Casts flagged, C...		<input type="checkbox"/>	ARK
Urine EPIS	28	H	/uL	0 - 4			<input type="checkbox"/>	ARK
Urine BACT	2449	H	/uL	0 - 9			<input type="checkbox"/>	ARK
Culture if Indicated	CX						<input type="checkbox"/>	
Remarks	NP				PERFORM MICRO. Crystals flagged. PER...		<input type="checkbox"/>	
Reviewed?	REVIEWED						<input type="checkbox"/>	

- 2 separate connections for 1 analyzer plus a 3rd analyzer for this area; Created rules to make them all work together
- Culture if Indicated rules assess if a culture is required

Hematology Workspace



System Configuration Diagnostics Security Specimen Management SSR DC SR MM MA Laboratory Intelligence Reports Window Help

Workspace Edit View Format Action Help

Specimen ID Patient ID Patient Name HEMATOLOGY 60 Comment

Specimen Worksheet

Specim...	Patient Name
032111	KNOWN,NAME
032110	UNI,NAME1
032113	TEST,SUMO
032112	HEALTH,TESTER
032178	DAY1,PYXSISES0
032286	WHITE,SNOW
032047	TEST,ONE

Patient Information

Patient Name: TEST,MARY
 Specimen ID: 032125
 Date of Birth: 12/7/2017
 Patient Age: 7 M
 Sex: F

Patient ID: M00001675
 Location - Facility: ER2ZONE Phone: 33029
 Location - Room:
 Ordering Physician:
 Collection Date/Time: 8/5/2018 12:13:00 AM
 Specimen Received Date/Time: 8/5/2018 12:13:00 AM

Account Number: H0000034546
 Instrument ID: DXH2
 Rack:
 Position: 00009
 Last Result to IM Date/Time: 8/5/2018 2:48:56 AM

Specimen Comments:
 Query: MO Blast,Perform MANUAL DIFFERENTIAL,

Test Worksheet

Test Name	Result	Flag	Units	Reference R...	Error Name(s)	Test Comment(s)	Rerun	Previous Result	Previous Res...	Test Instr...
* Pending										
- (none)										
DIFF CV							<input type="checkbox"/>			
RBC MORPH CV							<input type="checkbox"/>			
PLT EST CV							<input type="checkbox"/>			
- Rejected										
8/5/2018 2:48:56 AM										
ANC	2.480			10 ³ /...	2.34 - 6.44		<input type="checkbox"/>			DXH2
SEGS %	28.3			%	23.8 - 69.3		<input type="checkbox"/>			DXH2
LYMPHS %	52.0			%	13 - 70		<input type="checkbox"/>			DXH2
MONOS %	19.1	H		%	4 - 9		<input type="checkbox"/>			DXH2
EOS %	0.0	L		%	1 - 4		<input type="checkbox"/>			DXH2
BASOS %	0.6			%	0 - 1		<input type="checkbox"/>			DXH2
NRBC %	0.4	H		/100...	0.0 - 0.0		<input type="checkbox"/>			DXH2
LYMPHS #	4.551			10 ³ /...	2.03 - 5.68		<input type="checkbox"/>			DXH2
MONOS #	1.672	H		10 ³ /...	0.26 - 1.08		<input type="checkbox"/>			DXH2
EOS #	0.004	L		10 ³ /...	0.01 - 0.20		<input type="checkbox"/>			DXH2
BASOS #	0.052			10 ³ /...	0.01 - 0.06		<input type="checkbox"/>			DXH2
NRBC #	0.026			10 ³ /...	0.03 - 0.12		<input type="checkbox"/>			DXH2
- Released										
8/5/2018 2:48:56 AM										
WBC	8.8			10 ³ /...	4.9 - 17.1		<input type="checkbox"/>			DXH2
WBC uncorrected	8.8			10 ³ /...			<input type="checkbox"/>			DXH2
RBC	4.56			10 ⁶ /...	3.81 - 5.41		<input type="checkbox"/>			DXH2
HGB	10.1	L		g/dL	10.2 - 14.6		<input type="checkbox"/>			DXH2
HCT	30.5			%	29.6 - 43.3		<input type="checkbox"/>			DXH2
MCV	66.9	L		fL	70.7 - 90.7		<input type="checkbox"/>			DXH2
MCH	22.2			pg	22.8 - 26.0		<input type="checkbox"/>			DXH2

- Rules in Hematology configuration order Cellvision tests and automatically reject auto-differential
- Hematology analyzer working in conjunction with Cellvision

All Analyzers Workspace



- Color Formatting and Layout
- Creative Rule Writing: Methotrexate Screen test (9 Rules)

System Configuration Diagnostics Security Specimen Management SSR DC SR MM MA Laboratory Intelligence Reports Window Help

Workspace Edit View Format Action Help

Specimen ID Patient ID Patient Name ALL ANALYZERS 60 Comment

Specimen Worksheet

Specimen ID	Patient Name
Partial	
032147	NNN,JOSEPH
032146	TEST,CINDERELLA
032145	TEST,BERT
032144	TEST,BECKY
032125	TEST,MARY
032124	TEST,BABYNEW
032120	TEST,ADM
032121	TEST,BABY
Complete	
032294	Fieldtag,test
032291	JANUARY,TESTING
032295	RAIN,TEST
032276	DOE,JOHN
032255	LABACK,TEST
032254	TEST,ACCOUNT
032296	KNOWN,NAME
032292	PHA,TRAIN
032257	BBK,LAB1
032256	TEST,ADM
032282	CABO,LUIS
032281	BEAR,TEDDY
032271	BEAR,TEDDY
032274	CABO,LUIS
032269	BEAR,TEDDY
032272	BEAR,TEDDY
032273	DAY1,PYXSISES01
032270	BEAR,TEDDY
032264	Rachael,Test
032248	CALAMITY,GANON
032247	UMTESTNEWGOV,HN30
032246	ADM,TEST

Patient Information

Patient Name: CABO,LUIS Patient ID: M000001075 Account Number: H00000022210
 Location - Facility: ER4ZONE Phone: 35854 Instrument ID: C4
 Location - Room: Rack: H755
 Date of Birth: Ordering Physician: Position: 1
 Patient Age: Specimen Received Date/Time: 8/13/2018
 Sex: M Collection Date/Time: 8/13/2018 8:38:00 PM Last Result to IM Date/Time: 8/13/2018 9:
 Specimen Comment(s):
 Query:

Test Worksheet

Test Name	Result	Flag	Units	Reference R...	Error Name(s)	Test Comment(s)	Test Dilution	Rerun
* Rejected								
METHOTREXATE	>+111		umol/L		>,MTX SCREEN test is p...		STANDARD	<input type="checkbox"/>
MTX SCREEN	0.52		umol/L		Manually dilute 1:10 with ...		1:10	<input type="checkbox"/>
* Released								
METHOTREXATE	2.42		umol/L		Manual dilution was perf...		1:10	<input type="checkbox"/>

Run Worksheet

Status Display Rules Setup - ARCHITECT20170810

ARCHITECT20170810 Panes

Tree View

Enter Find Text Replace... Protect Rule

- [-] [11] 8.10 Format Methotrexate Results 20170601
 - [-] If:
 - [-] [11] Then:
 - [-] [0] 8.10.1 Order MTX Screen 20170601
 - [-] [3] 8.10.2 Manual Dilution for MTX 20170601
 - [-] If:
 - [-] [3] Then:
 - [-] [0] 8.10.2.1 Result is >
 - [-] [0] 8.10.2.2 Result is <
 - [-] [0] 8.10.2.3 Result is numeric
 - [0] Else:
 - [-] [3] 8.10.3 Format MTX1000 Test 20170601
 - [-] If:
 - [-] [3] Then:
 - [-] [0] 8.10.3.1 Multiply by Dil Factor 20170601
 - [-] [0] 8.10.3.2 Format Upper Limit 20170601
 - [-] [0] 8.10.3.3 Set Test Name 20170601
 - [0] Else:
 - [-] [0] 8.10.4 Format MTX Lower Limit 20170601
 - [-] [0] 8.10.5 Hold All Methotrexate Results 20170601
 - [0] Else:

Articles of interest



- AUTO10-A Autoverification of Clinical Laboratory Test Results; Approved Guideline; CLSI, October 2006
- Marquardt, Bill; A Step-by-step Process to 95% Autoverification; CAP Today, Dec 2015
- Paxton, Anne; Beyond Connectivity: Middleware's Shifting Shape; CAP Today, Apr 2016

Questions?

