

CRYSTAL CREAM AND BUTTER COMPANY

W.O. 11494

SACRAMENTO, CALIFORNIA

APRIL 10, 1978

OPERATING INSTRUCTIONS

FOR

APV DOUBLE EFFECT FALLING FILM
MECHANICAL RECOMPRESSION EVAPORATOR AND
AN HTST DAIRY PASTEURIZING SYSTEM

Operators must read and understand these instructions. Before you turn a valve, push a button, or adjust an instrument, make sure you know what will happen.

All pumps must be primed with water and pump seal water valves opened prior to all rotational check or operation.

Operating temperatures and pressures contained herein are to be used only on initial start-up. Field tests will verify operating conditions. Sequential operation may be changed.

I. General:

The APV FF Evaporator concentrates liquor by employing the "falling film" principle for performing the evaporation. Evaporation takes place by heating the liquor as it falls freely between gasketed rectangular plates, and then passing the heated liquor into a separator that is maintained at a relatively high vacuum (i.e. 26"-28" Hg. vacuum). Heating is performed by transferring heat through the plates by condensing vapors on the opposite side of the plates. The plates are arranged in "Plate Units", each plate unit consists of two (2) plates, thereby allowing an annular steam passage on each side of the annular liquor passage. Because of gasket location, liquor cannot intermix with steam and vice versa. Evaporation duties may easily be altered by adding or subtracting "Plate Units" thereby creating an inherent flexible APV System. Further, heating surfaces may easily be observed simply by opening the "Plate Pack".

The present system utilizes mechanical recompression of the vapors obtained from the liquid being evaporated as the source of energy. The compressed vapors, being at a higher energy level and its associated higher temperature, are then able to yield the required ΔT needed for the evaporation. An auxiliary start-up steam source, however, is required.

A standard APV 3-A Pasteurizing System is used for pasteurizing the milk feed liquor prior to the evaporator. Necessary safeguards are built into the system such that unpasteurized milk products cannot flow to the evaporator.

II. Major Components- (All Frames are of the Falling Film Type)

1. 1st Effect, Frame size 3:1, 58 PU's* w/54 diam. reversed dished head.
2. 2nd Effect, Frame size 1:2, 26 PU's*, w/36" diam. reversed dished head.
3. One (1) Roots Mechanical Compressor
4. One (1) Compressor Snubber
5. One (1) 4 Stage HX-6 APV Plate Heat Exchanger
6. One (1) 2 Stage HX-6 APV Plate Heat Exchanger
7. One (1) 1 Stage HXCB-6 APV Plate Heat Exchanger
8. Two (2) Feed Balance Tanks
9. One (1) Shell and Tube Condenser
10. One (1) Vacuum Pump
11. One (1) APV Hot Water Recirculating System
12. One (1) Panel
13. Necessary pumps, piping, vapor ducts, etc. required for a complete package dairy HTST and evaporator system (holding loop not included).
14. Necessary pneumatic instruments and in-situ thermometers, and pressure/vacuum gages required for efficient operation.

* PU's means Plate Units.

III. Specifications-

	<u>Skim Milk</u>	<u>Whey</u>
1. Feed Rate (lbs/hr)	18,190	15,007
2. Feed Concentration (% T.S.*)	8.5	6.0
3. Feed Temperature (°F)	40	110
4. Product Rate (lbs/hr)	6184	3001
5. Product Concentration (% T.S.*)	25	30
6. Product Temperature (°F)	38	38
7. Evaporation Rate (% T.S.*)	12,006	12,006

* T.S. Means Total Solids

Schematic: Mechanical Vapor Recompression
 Evaporator
 Crystal Cream and Butter Co.
 Sacramento, California
 Drawing No. PE4-5984-B

IV. Operating Design of Evaporator

The present design utilizes a constant recompressed vapor flow to the evaporator steam headers (via constant evaporating pressure) to do the evaporating and manually varying the feed rate in order to maintain product specifications. Thus, with a constant vapor flow, an increase in feed rate will lower or decrease product solids and vice versa. A manually adjusted control valve is used for varying the feed rate.

V. Instrumentation for Evaporator

A. Evaporating Pressure Control

A constant vapor flow to the evaporator is maintained by employing a Vent Heater Controller and a pneumatically operated vapor control valve.

The controller is used to monitor the absolute pressure (equilibrium temperature) at the liquor boiling point and pneumatically controlling a vent heater control valve for maintaining a constant evaporating temperature. The set-point on the controller, however, is manually adjusted.

B. Feed Rate Control

The feed rate to the evaporator is controlled by manually adjusting an APV Graduated Control Valve (GCV). The control valve is built like a mechanics micrometer and can be set accordingly.

#8 PES-6067

C. Feed Pre-Heat Control

From HTST System

D. Condensing and Vacuum System

A vacuum pump in conjunction with a shell and tube condenser are used to provide the necessary vacuum and condensing for evaporation, respectively.

E. System Vacuum Control

The evaporator system vacuum is maintained constant by employing an autonomous Fisher 630 R vacuum relief valve. This valve is connected to the vapor duct connecting the condenser to the evaporator. Since the vacuum produced by the vacuum system pulls more than is desired, the Fisher vacuum control valve opens and allows atmospheric air to enter the system in order to obtain the desired vacuum. (Initially, this valve will have to be adjusted for obtaining 26.5 - 27.0" Hg.) (i.e.-the equivalent boiling point is 120-115°F.)

VI. Instrumentation for HTST System

A. HTST Pasteurizer

A standard APV 3-A HTST Pasteurizer provides pasteurized milk feed liquor to flow to the evaporator. A standard HTST Taylor Controller and its associated divert valves are used to insure unpasteurized milk products from leaving the HTST system.

B. Pasteurization Temperature (Evaporator Feed Pre-Heater)

Two APV Plate Heat Exchangers are used to reclaim all available heat within the system before final pasteurization temperature is reached. An APV Hot Water Recirculating System is used for heating the feed liquor to reach pasteurizing temperature before it enters the holding loop. A Taylor Controller and its associated steam temperature control valve are used for maintaining a constant hot water temperature of the recirculating system.

VII. OPERATING INSTRUCTIONS

A. START-UP CHECK LIST

1. Be sure plate evaporator tie bolts on each effect are tightened.
NOTE: Tighten tie bolts only sufficiently enough to obtain a vacuum.
2. Be sure 2-HX-6's and HXCB-6 Plate Heat Exchanger tie bolts are tightened.
NOTE: Note 3 on each of drawings 8661, 8662, and 8663 states the following: Tighten machine only sufficiently to prevent leakage at operating pressure. Do not tighten below the platage dimension shown.
3. Be sure ~~stop valve located~~ in steam line leading to Spence Regulator used for superheater is closed.
4. Open all pump seal water valves such that a little water is *installe* draining to floor from all pumps that require seal water. *selectin*
9 spw
5. Open vacuum breaker valve located on 1st effect steam header.
6. Close feed Graduated Control Valve (GCV).
7. Set 3-way product discharge flow valve from HTST for flow to drain at HTST balance tank.
8. Set "HTST "Auto/Manual" selection switch for "Auto."
NOTE: A) Flow from HTST system will now be in forward flow position since evaporator feed tank is empty.
B) When in Manual position, flow will be diverted back to HTST feed balance tank.
9. Set 3-way product discharge flow valves from evaporator for flow to drain at evaporator feed balance tank.
10. Open air supply valve and adjust following regulators:
 - A) Norgren: Adjust for output pressure of 20 PSIG.
 - B) Fisher: Adjust for output of 60 PSIG. (For Vapor Compression Suction Valve.)
 - C) Fisher: Adjust for output of 40 PSIG. (For Taylor Flow Diversion Valves).
11. HTST CONTROLLER
 - A) Adjust milk set-pointer to pasteurizing temperature.
 - B) Adjust hot water set-pointer to center of scale.

12. VENT HEATER CONTROLLER

A) Set Auto/Manual Switch to Manual.

B) Adjust manual wheel until output gage reads 15 PSIG.

NOTE: Vent heater valve should now be fully open. Visually verify.

13. Set "Start-Up By Pass Valve" selector switch to OPEN.

14. Set "Snubber Drain Valve" selector switch to OPEN.

15. Set "Fresh Water Inlet Valve" selector switch to CLOSE.

16. Set "Fresh Water Heater Valve" selector switch to CLOSE.

17. Adjust "Vapor Compression Suction Valve" output gage to 0 PSIG.

NOTE: Compressor suction valve is Air-to-Open. Valve should now be closed. Visually verify.

18. Adjust "Start-Up Steam Valve" output gage to 0 PSIG.

NOTE: Start-up steam valve is Air-to-Open. Valve should now be closed. Visually verify.

19. Set 3-way discharge valve located after condensate pump to discharge through both HX Heat Exchangers.

20. Open fully desuperheat valve that is located in line connecting condensate pump discharge to vapor duct leading to both effect steam headers.

NOTE: Later, when operating at design conditions, this valve may be adjusted such that temperature and pressure correspond to saturated steam conditions as shown on the attached steam tables.

21. Open fully condenser outlet cooling water valve.

22. Open condenser inlet cooling water valve 2 turns.

NOTE: Later, when operating at design conditions, adjust inlet valve such that vapor temperature leading to vacuum pump does not exceed 100°F.

23. Open fully 2 vent valves that are located in the vent lines that connect the condensate outlet plenum from each effect to the condenser vapor inlet bonnet.

24. ROBERTSHAW TEMPERATURE CONTROLLER

A) Adjust set-pointer to 120°F.

NOTE: Since temperature in water line is less than 120°F, steam control valve leading to steam inspection nozzle should be fully open. Visually verify.

25. Open water stop valve leading to HTST feed balance tank
26. Open water balance tank stop valve in fresh water line leading to HXCB-6 heat exchanger.
27. Open water stop valve leading to vacuum pump.
28. Open petcock located on side of vacuum pump.
29. Turn-on "Power" selector switch.

NOTE: A) Since HTST feed balance tank is empty, solenoid valve in water line will open and admit water until top probe is covered and then close.

B. CIRCULATE WATER THRU HTST SYSTEM

1. Turn on Timing Pump
2. Observe drop in level in HTST feed balance tank and automatic water solenoid valve opening.
3. Observe water flowing to drain at HTST feed balance tank.
4. Adjust Timing Pump RPM as required in order to have a good flow of water flowing to drain.
5. Check for leaks in product piping and in HX machines. Tighten machines as required.
6. Thoroughly flush the system.

C. CIRCULATE WATER THRU EVAPORATOR

1. Set "Fresh Water Inlet Water" selector switch to open.
NOTE: Observe water entering evaporator feed balance tank.
2. Turn-on Evaporator Feed Pump.
3. Gradually open GCV to a setting of 4.5.

NOTE: A) The GCV valve does not have a positive stop on it to prevent the plug from turning fully out of the valve. Do Not Open Valve To A Setting Greater Than 10.

NOTE: B) Adjust feed control fresh water valve for flow of water entering HXCB-6 such that top probe in evaporator feed tank always remains covered.

4. Turn on following pumps:
 - a) 1st Effect Recirculation
 - b) 1st Effect Extraction
 - c) 2nd Effect Recirculation
 - d) 2nd Effect Extraction
5. Observe water flowing to drain at evaporator feed tank.
6. Look for leaks in piping system and in plate packs of units and HX machines. Tighten as required.
7. Adjust GCV as required such that a good flow of water is flowing through all separators but that the separators do not flood.
8. Thoroughly flush the system.

D. SANITIZE PROCESS LINES (HTST SYSTEM)

1. Set 3-way product outlet valve from HTST system for recycle to HTST feed balance tank.
2. Start adding sanitizing solution to feed balance tank.

NOTE: Plant personnel will dictate proper procedure to use. Sanitizer must always be added as a liquid, never a solid. If sanitizer contains a chloride, do not heat or start evaporating.
3. Continue to recirculate for ten (10) minutes or as dictated by plant personnel.
4. At end of ten (10) minutes, set product discharge valves for flow to drain.
5. Thoroughly flush the system.

E. SANITIZE PROCESS LINES (EVAPORATOR SYSTEM)

1. Repeat Item D, Steps 1 thru 5, for evaporator system instead of HTST system.

NOTE: During this time, check out lines leading to product storage tank. Sanitizing solution from evaporator can be used for sanitizing these lines and product storage tank. Open bottom drain valve on storage tank if it is empty.

2. Thoroughly flush lines leading to product storage tank. When flushed, set 3-way valves for flow to drain at evaporator feed tank. Close storage tank discharge valve..

F. START-UP HOT WATER CIRCULATING SYSTEM

1. Open vent valve.
2. Open water make-up valve until water starts to flow out of vent valve.
3. Turn-on Hot Water Pump.
4. Close vent valve.

G. START HEATING HTST SYSTEM

1. Gradually open steam stop valve leading to hot water set.
 - a) Steam should now pass thru control valve until lowest temperature on HTST controller is reached and then close.
2. HTST CONTROLLER
 - a) Gradually adjust hot water temperature set-pointer to 155°F.
3. Adjust "Timing Pump" as required.

H. START HEATING EVAPORATOR SYSTEM

1. Set "Fresh Water Heater Valve" selector switch to open.
NOTE: Observe steam entering through steam control valve until fresh water reaches 120°F.
2. ROBERTSHAW TEMPERATURE CONTROLLER
 - a) Gradually adjust knob to a temperature of 168°F.

I. EVACUATE THE SYSTEM

1. Open manual drain valve located on bottom of snubber.
2. Open start-up steam valve and steam-out for ten (10) minutes.
NOTE: Observe steam leaving at vacuum breaker valve and from manual valve located at bottom of snubber.
3. At end of ten (10) minutes, close vacuum breaker valve and manual valve located at bottom on snubber.
4. Start vacuum pump
NOTE: When vacuum pump is started, solenoid valve located in water line will open and allow water to flow to vacuum pump.
5. Close valve located on side of vacuum pump.
6. Observe increase in vacuum on vacuum gages located on vapor duct leading to steam headers and on vapor duct leaving 2nd effect separator.
7. When vacuum reaches 25.5" Hg (equivalent to 130°F. temperature), adjust Fisher 630R regulator such that vacuum holds constant.

J. START COMPRESSOR AND EVAPORATION

1. Gradually open steam stop valve leading to Spence regulator for adding steam to superheater.
 - a) Initially, the Spence will have to be regulated for a downstream pressure of 30 PSIG.
2. Set "Start Up By-Pass" selector switch to close.
3. Set "Snubber Drain Valve" selector switch to close.

4. Start Vent Heater Condensate Pump.
5. Start Main Condensate Pump.
6. Start Compressor.
 - a) Observe compressor amps on panel meter.
7. Vapor Compression Suction Valve
 - a) Gradually increase output pressure until valve is wide open.
NOTE: (Initially, on a "dead-system", the required air output to fully open valve should be determined).
8. Vent Heater Controller (Controller on Manual)
 - a) Gradually adjust manual wheel to decrease output to valve until process pointer on controller reads 10.4" Hg absolute (equivalent to 163°F).
 - b) When 10.4" Hg absolute is reached, adjust set-pointer to 10.4" Hg and switch to Auto.

K. SWITCH HTST FLOW TO EVAPORATOR FEED TANK

1. HTST CONTROLLER

- a) Gradually adjust hot waer set pointer to 168°F.
NOTE: When pasteurizing temperature circulating in HTST is reached, both flow diversion valves will switch to forward flow.
2. Set "Fresh Water Inlet Valve" selector switch to Close.
3. Set "Fresh Water Heater Valve" selector switch to Close.
4. Robertshaw Temperature Controller
 - a) Set knob to 120°F.
5. Gradually close the "Start-Up Steam Valve".
6. The system must balance out evaporating on water before proceeding.
7. Adjust feed GCV as required.
8. Adjust Timing Pump as required.
9. Set 3-way product discharge flow valve from HTST for flow back to HTST feed balance tank.

L. EVAPORATE FEED LIQUOR i.e. SKIM MILK, WHEY, BUTTERMILK

1. Start feed liquor pump.
2. Open feed liquor pump for flow to HTST feed balance tank.
NOTE: Observe water solenoid valve shuts off as level rises in HTST feed balance tank.
3. Observe flow of feed liquor entering evaporator feed tank.
4. When feed liquor is observed flowing to drain at evaporator feed balance tank, set 3-way product discharge valves for recycle to feed balance tank.
5. Gradually adjust GCV and Timing Pump for increasing product solids. Closing GCV (and decreasing RPM of Timing Pump) will increase product solids and vice versus.
6. Observe increase in product solids.
7. When product is 1 to 2% below specifications set 3-way product valves for flow to storage tank.

NOTE: a) Product must be sent forward before final specifications are reached otherwise overconcentration will occur. Later, a slight overconcentration will correct final product total solids in storage tank.

b) When product is sent "Forward", a slight upset will occur since concentrated product will no longer be returned to balance tank; the GCV must now necessarily be adjusted to increase or decrease the product percent total solids as required. i.e. opening GCV will lower product total solids and vice versa.

8. Gradually open cooling water valve leading to 4 stage HX Plate Heat Exchanger.

9. Operating conditions are as follows:

(Field Trials to Verify)

	<u>SKIM MILK</u>	<u>WHEY</u>
a) Feed Rate (lbs/hr)	18,190	15,007
b) Feed Concentration (%T.S.*)	8.5	6.0
c) Feed Temperature (°F)	40	110
d) Compressor Suction Temp. (°F)	150	150
e) Compressor Discharge Temp. (°F)	163	163
f) System vacuum at separators ("Hg)	22.3	22.3
g) Product Rate (lbs/Hr)	6184	3001
h) Product Concentration (%T.S.*)	25	30
i) Product Temperature (°F)	38	< 38
j) Evaporation Rate (lbs/hr)	12,006	12,006

* T.S. means Total Solids

10. Record on data sheet all data as required by plant personnel.
11. Continue evaporation. Adjust GCV and Timing Pump as required for obtaining product specifications.

M. SHUT-DOWN FOR WASH-UP

1. When plant feed tank runs empty or at the end of a 20 hour run, shut-off feed valve. Observe drop in level in HTST feed balance tank and water entering through solenoid.
2. Observe water entering evaporator feed balance tank.
3. Observe fall off of percent solids in product.
4. When product reaches percent solids as dictated by plant personnel, set 3-way product discharge valves located at evaporator feed balance tank for discharging to drain, or to temporary storage tank for later re-run.
5. Divert flow to drain at evaporator feed tank.

6. Set "Fresh Water Inlet Valve" selector switch to open.
7. Set "Fresh Water Heater Valve" selector switch to open.
8. ROBERTSHAW TEMPERATURE CONTROLLER
 - a) Gradually increase temperature knob to 165°F.
9. Set "HTST Auto/Manual" selector switch to Manual.

NOTE: Flow from HTST is now diverted to enter HTST feed balance tank.
10. Set 3-way product outlet valve located at HTST feed balance tank for drain to floor.
11. Close water stop valve leading to cooling section of 4 Stage HX-6 Plate Heat Exchanger.

NOTE: Thus, each system now has its own water supply and wash-up can be done independently of the other.

N. CAUSTIC WASH-UP FOR HTST SYSTEM

1. Dissolve sufficient flake caustic, or equivalent, such that the resulting solution when added to the HTST system will be approximately 1½ to 2% caustic. Dissolve caustic in several pails of cold water. Add only dissolved solution to the HTST feed balance tank.

NOTE: Be careful-wear rubber gloves, eye glasses, and face shield. Stir while adding caustic. Caustic reacts with water to give a high heat of dissolution.
2. Gradually add dissolved caustic to HTST feed balance tank.
3. Set 3-way product valves for recycle to balance tank.
4. Continue to recycle for ten (10) minutes.
5. At end of ten (10) minutes, set 3-way product discharge valves for flow to drain.
6. Thoroughly flush the system.

O. CAUSTIC WASH-UP FOR EVAPORATOR SYSTEM

1. Repeat Item N, Steps 1 thru 6 for evaporator system.
2. While adding caustic to evaporator feed balance tank, adjust Vent Heater Controller set-pointer to 12" Hg. absolute; (equivalent boiling point is 170°F.)
3. (In conjunction with both wash-ups, setting "HTST Auto/Manual" selector switch to Auto several times will clean the line connecting both systems).

P. SHUT-DOWN HTST SYSTEM

1. HTST CONTROLLER

- a) Gradually adjust hot water set-pointer to center of scale.
2. Close steam stop valve leading to steam control valve of hot water recirculating system.
3. Shut-off hot water circulating pump.
4. Shut-off Timing Pump.
5. Close water stop valve located in water line leading to HTST feed balance tank.

Q. SHUT-DOWN EVAPORATOR SYSTEM

I. ROBERTSHAW TEMPERATURE CONTROLLER

- a) Set temperature knob to lowest temperature.
2. Close steam stop valve leading to S & K steam injector.
3. Set "Start-Up By-Pass Valve" selector switch to open.
4. Set "Snubber Drain Valve" selector switch to open.
5. Shut-off Compressor.
6. Shut-off steam stop valve leading to superheater.
7. Open vacuum breaker located on vapor duct leading to both effect steam headers.
8. When vacuum reaches 5" Hg. on vacuum gages, shut-off Vacuum Pump.

9. Set "Fresh Water Inlet Valve" selector switch to Close.
10. Set "Fresh Water Heater Valve" selector switch to Close.
11. VENT HEATER CONTROLLER
 - a) Set Auto/Manual selector switch to Manual.
 - b) Adjust manual wheel until output gage reads 20 PSI.
12. VAPOR COMPRESSION SUCTION VALVE
 - a) Adjust knob for 0 PSIG.
13. Close feed GCV.
14. Shut-off following pumps:
 - a) Feed Pump
 - b) 1st Effect Recirculation
 - c) 1st Effect Extraction
 - d) 2nd Effect Recirculation
 - e) 2nd Effect Extraction
 - f) Vent Heater Condensate
 - g) Main Condensate
15. Close water stop valve leading to vacuum pump.
16. Close cooling water inlet valve leading to condenser.
17. Open manual drain valve located at bottom of snubber.

R. C I P EVAPORATOR

1. Open CIP valve leading to 1st effect separator.
2. Open CIP valve leading to 2nd effect separator.
3. Set 3-way product discharge valves located at evaporator feed balance tank for recycle.
4. Start CIP solution flowing to evaporator feed tank.
5. Start Feed Pump.
6. Gradually open GCV to a setting of 4.5.

7. Start following pumps:
 - a) 1st Effect Recirculation
 - b) 1st Effect Extraction
 - c) 2nd Effect Recirculation
 - d) 2nd Effect Extraction
8. Continue to recirculate as directed by plant personnel.
9. After CIP, set 3-way product discharge valves for flow to drain.
10. Start fresh water flow to CIP system.
11. Thoroughly flush system.
12. Shut-off Feed Pump.
13. Close feed GCV.
14. Shut-off following pumps:
 - a) 1st Effect Recirculation
 - b) 1st Effect Extraction
 - c) 2nd Effect Recirculation
 - d) 2nd Effect Extraction
15. Close CIP valves leading to both separators.
16. Shut-off main pump seal water.
17. Close main air supply valve.
18. Shut-off "Power" switch.


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Fig. Year	Wg. Area	Temp.	Current, Feet 210/16	Wg. Balance 210/16
0	30	212	971	26.8
1	29	210.3	972	27.7
2	28	208.6	973	28.7
3	27	206.8	974	29.7
4	26	205	975	30.7
5	25	203	977	31.9
6	24	201	978	33.1
6.6	23.4	200		
7	23	198.9	979	34.4
8	22	196.8	980	35.9
8.8	21.2	195		
9	21	194.5	982	37.5
10	20	192.2	983	39.2
10.9	19.1	190		
11	19	189.8	985	41.2
12	18	187.3	986	43.3
12.85	17.15	185		
13	17	184.7	988	45.7
14	16	181.9	989	48.4
14.7	15.3	180		
15	15	178.9	991	51.4
16	14	175.9	993	54.8
16.35	13.65	175		
17	13	172.7	995	58.8
17.8	12.2	170		
18	12	169.2	997	63.3
19	11	165.4	999	68.7
19.15	10.85	165		
20	10	161.4	1002	75.1
20.35	9.65	160		
21	9	157.0	1004	82.9
21.45	8.55	155		
21.5	8.5	154.6	1006	87.5
22	8	152.1	1007	92.6
22.4	7.6	150		
22.5	7.5	149.5	1009	98.4
23	7	146.8	1010	105
23.3	6.7	145		
23.5	6.5	143.8	1012	112
24	6	140.7	1014	121
24.13	5.87	140		
24.5	5.5	137.3	1016	132
24.67	5.33	135		
25	5	133.6	1018	144
25.47	4.53	130		
25.5	4.5	129.7	1020	159
26	4	125.0	1023	177
26.55	3.45	120	1026	201
27	3	115	1029	223
27.4	2.6	110	1032	
27.83	2.17	105	1035	205