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PROBLEM OF HIGH FLUCTUATION IN SPEED DUE TO REDUCTION IN EXTRACTION STEAM FLOW

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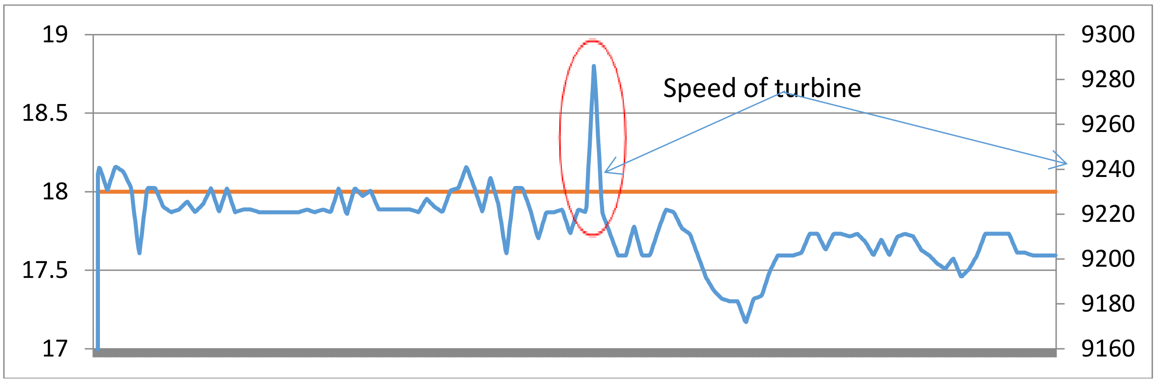
ABSTRACT

Turbine governing is designed for maintaining given speed on desired load or variation of load. When the power generation/speed fluctuates from its desired value or governor not able to maintain turbine speed, plant operation becomes unreliable to the operators. So the maintenance of any governing system is a tedious job which requires very wise full decisions for its component overhauling and replacement, it requires vast practical knowledge and equipment behavior. After one start up of plant, taking a shutdown is very costly affair to afford huge cost of loss of primary content for a big process industry due to a very minute problem, is not easy to justify. After observing any problem in the system, it is not easy task to identify the correct cause of the problem because there are so many linking of the parameters to each other. Problem of hunting of control valves and hunting of speed is faced by many industries in the past years and now they have sufficient knowledge about it but high oscillation in speed after a fix point of reduction in extraction steam is new type of problem. Variation in speed around 200 rpm creates fluctuation in compressor discharge flow and pressure due to which all the parameter deviates from its normal value so either plant to be tripped or plant load should be reduced.

Keywords: HP& LP Valve- high pressure steam inlet valve & Low pressure steam inlet valve , DCS-distributed controlling system.

I. INTRODUCTION

Normally, governor or governing system is having problem if speed fluctuation occurs in the steam turbine at constant compressor load because governor is designed to maintain the speed. Now days for smooth controlling of speed of a steam turbine electronics governor is used which replaced the old mechanicalhydraulic governor. It's claimed by the electronic governor manufacturer that these governors are more sensitive, these have more quick controlling power than old one. This is a classical problem of a SYN gas turbine in which electronic governor is in use and speed fluctuation occurs.



As shown in graph speed (Blue line) have taken sudden jump in graph, change in speed is around 80 RPM as per graph but in real it is of 200RPM (due to average value of 4 second it is less in graph). While no change in speed command given to governor by any signal. This new type of problem is faced in extraction cum condensing turbine. On 17th nov17 plant is also forced to trip on the same condition, we observe that turbine speed suddenly came down to 1000 rpm and turbine could not retain the speed again data is as per below detail
DCS Observations-

```
17-Nov-17  20:38:19 RPT001: ALARM     :                           Demanded : Page
1

      ALARM

      Category: All Activity
      Event location: On-Line
      Asset: *
      Source: *
      Description: *
      Operator: *
      Period: 17-Nov-17  11:00:00  to  17-Nov-17  15:00:00


 Time                            Source              Condition  Action    Level
Description                       Value      Units          Operator
 ---------------------------------------------------------------------------
-----------------------------------------------------------


 17-Nov-17  20:38:19 RPT001: ALARM      :                        Demanded :
Page    3

 Time                            Source              Condition  Action    Level
Description                       Value      Units          Operator
 ---------------------------------------------------------------------------
------------------------------------------------------------(Value   Deleted
due to confidential Data)

 11/17/2017 11:22:11.789 H2_07             PVHI                    L 00   H2 AT
04-HV-609 TOP
 11/17/2017 11:22:14.220 H2_07             PVHI        ACK         L 00   PVHI
LOW   ~
```

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```
 11/17/2017 11:22:15.640 H2_07                 PVHI        OK          L 00   H2 AT
04-HV-609 TOP
 11/17/2017 11:22:34.242 03TT346B               PVLL        OK          H 00   LO
COOLER O/L TEMP P301B
 11/17/2017 11:23:20.026 03IT301A              PVROCP                  L 00   CURRENT
IN 03MP-301A
 11/17/2017 11:23:25.566 03IT301A               PVROCP     ACK         L 00   PVROCP
LOW    ~
 11/17/2017 11:23:45.526 03IT301A              PVROCP      OK          L 00   CURRENT
IN 03MP-301A
 11/17/2017 11:24:49.751 02TE45A               BADPV       OK          L 00   REF GAS
FROM H-201
 11/17/2017 11:25:56.790 05TC99                 PVHH        OK          H 00   TOP
TEMP CNTRL IN F-521
 11/17/2017 11:27:21.777 02PDT363               PVHI                    H 00   DP
ACROSS R-202B
 11/17/2017 11:27:22.777 02PDT363               PVHH                    U 00   DP
ACROSS R-202B
 11/17/2017 11:27:23.527 02PDT365               PVHI                    H 00   DP
ACROSS HDS REACTOR
 11/17/2017 11:27:26.527 02FC19                PVLO                    H 00   STEAM
FEED TO REF.
 11/17/2017 11:27:28.527 03FI76                   PVHI                     L 00
CORRECTED FLOW 03FT76
 11/17/2017 11:27:29.027 04ST650               PVLO                    L 00   SPEED
MEASURE. TK-431          8887.39
 11/17/2017 11:27:29.527 02PDT363               PVHH        OK          U 00   DP
ACROSS R-202B
 11/17/2017 11:27:29.527 02PDT363               PVHI        OK          H 00   DP
ACROSS R-202B
 11/17/2017 11:27:29.527 04PT693                PVHI        OK          H 00   2ND
STAGE DISCH K-431          73.587
 11/17/2017 11:27:30.026 02PDT365              PVHI        ACK         H 00   PVHI
HIGH   ~
 11/17/2017 11:27:30.026 02PDT363              PVHH        ACK         U 00   PVHH
EMERGN~
 11/17/2017 11:27:30.026 02PDT363              PVHI        ACK         H 00   PVHI
HIGH   ~
 11/17/2017 11:27:30.027 04PT642               PVHI                    L 00   WHEEL
CHAMBER PRESR K431       74.074
 11/17/2017 11:27:30.027 04PT642               PVHH                    H 00   WHEEL
CHAMBER PRESR K431       74.074
 11/17/2017 11:27:30.027 03FI76                PVHI        ACK         L 00   PVHI
LOW    ~
 11/17/2017 11:27:30.028 02FC19                PVLO        ACK         H 00   PVLO
HIGH   ~
 11/17/2017 11:27:30.381 02PDT365              PVHI        ACK         H 00   PVHI
HIGH   ~
 11/17/2017 11:27:30.381 02PDT363              PVHH        ACK         U 00   PVHH
EMERGN~
 11/17/2017 11:27:30.381 02PDT363              PVHI        ACK         H 00   PVHI
HIGH   ~
 11/17/2017 11:27:30.382 03FI76                PVHI        ACK         L 00   PVHI
LOW    ~
 11/17/2017 11:27:30.383 02FC19                PVLO        ACK         H 00   PVLO
HIGH   ~
```

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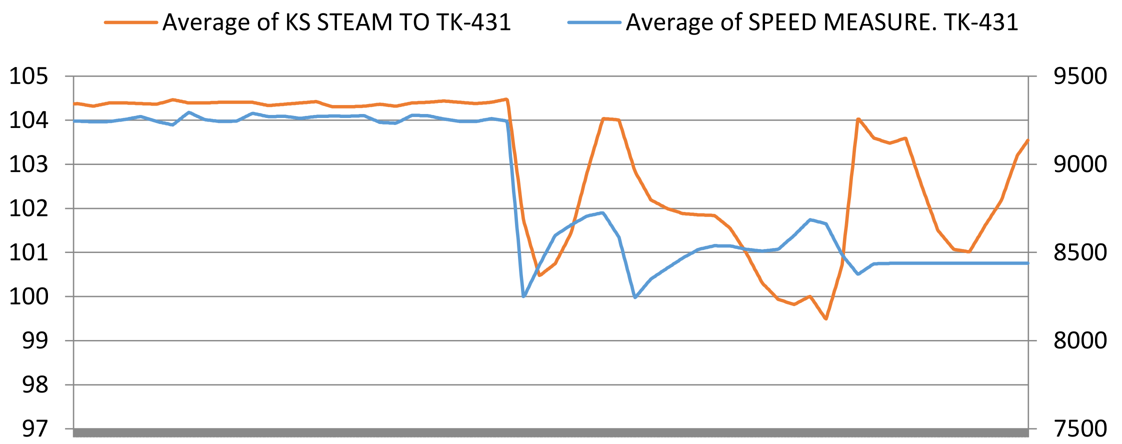
11/17/2017 11:27:30.527 02PDT365 PVHI OK H 00 DP
ACROSS HDS REACTOR
11/17/2017 11:27:30.527 03FI76 PVHI OK L 00
CORRECTED FLOW 03FT76 257655.
11/17/2017 11:27:30.527 04PC610 PVHI L 00 1ST
STAGE SUCTION VENT
11/17/2017 11:27:30.600 04H821 CHNGOFST L 00 K431
RESET SURGE COUNT OFF
11/17/2017 11:27:30.600 04H821 CHNGOFST OK L 00 K431
RESET SURGE COUNT OFF
11/17/2017 11:27:30.630 04CA822 CHNGOFST U 00 K431
SAFETY ON ON
11/17/2017 11:27:30.630 04CA822 CHNGOFST OK U 00 K431
SAFETY ON ON
11/17/2017 11:27:30.630 04CA823 OFFNORM U 00 K431
RECYCLE TRIP TRIP
11/17/2017 11:27:30.777 04PT694 PVHI L 00 1ST
STAGE SUCTION K-431 28.279
11/17/2017 11:27:30.777 04FT311 PVHI H 00 MP
STEAM EXIT TK-431 196485.
11/17/2017 11:27:31.027 04PC647C PVHI H 00
EXTR.STEAM PR. TK-431 41.645
11/17/2017 11:27:31.027 04PC647C DEVHI H 00
EXTR.STEAM PR. TK-431
11/17/2017 11:27:31.027 02PC308 PVHI L 00 HS
HEADER PRESS CNTRL 41.058
11/17/2017 11:27:31.027 02PC308 DEVHI H 00 HS
HEADER PRESS CNTRL 41.058



Plant load is continuously increasing and therefore turbine load is also increasing. In case of condensing cum extraction type of turbine it becomes very tuff to analyze and find the root cause of problem because there are so many interlocks. This case is classical example of a SYN gas compressor turbine. Turbine model is –ENHK-40/40-3.

In this paper we will find the problem behind speed fluctuations even electronic governor is controlling turbine and turbine is running well from long time.

II. BACKGROUND OF THE EQUIPMENT

Turbine was installed in the 1994 and after commissioning it was running successfully without any problem. Turbine was of 23megawatt power at the time of commission and in 2008 it is upgraded from 23 to 30.4 megawatt by OEM and Governor was replaced from mechanical to electronic type. After that, it is running successfully at its

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max rated power is 28 megawatt. Here past history is mentioned for the better understanding that how industrial demands are increasing.

This problem was first appeared in the month of October 2016 when process demanded to decrease the extraction steam and process people given signal to the governor. Turbine was running with 65T/h extraction.

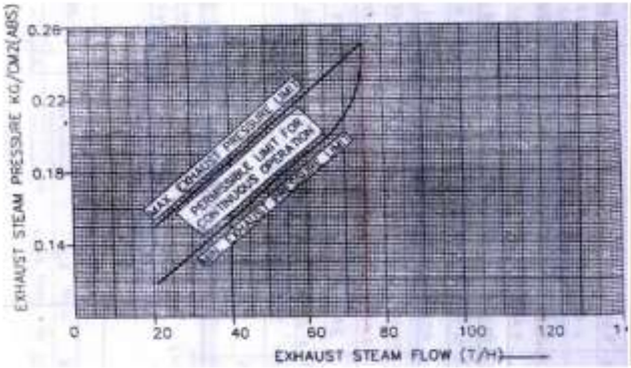
III. ANALYSIS OF THE PROBLEM

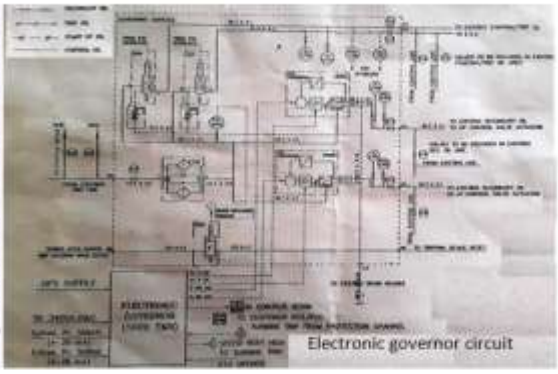
In first step, we checked past history for looking turbine behavior in past for same load (same compressor load and speed of turbine), which was found in year 2010 as below sheet.

Date / Time	Speed	Condenser load	Date / Time	Speed	Condenser load	Date / Time	Speed	Condenser load	Date / Time	Speed	Condenser load	Date / Time	Speed	Condenser load	Date / Time	Speed	Condenser load
12/1/2010	9255	69.0	12/16/2010	9300	71.0	12/31/2010	9358	70.8	1/15/2011	9393	71.9	1/30/2011	9332	72.0	2/14/2011	9281	65.6
12/2/2010	9280	70.0	12/17/2010	9297	71.5	1/1/2011	9343	72.2	1/16/2011	9350	71.7	1/31/2011	9333	71.3	2/15/2011	9265	65.4
12/3/2010	9279	70.6	12/18/2010	9297	71.7	1/2/2011	9346	72.8	1/17/2011	9350	71.3	2/1/2011	9335	71.3	2/16/2011	9304	65.4
12/4/2010	9293	71.3	12/19/2010	9293	71.0	1/3/2011	9216	68.3	1/18/2011	9367	71.9	2/2/2011	9339	69.3	2/17/2011	9312	62.8
12/5/2010	9293	71.4	12/20/2010	9298	70.8	1/4/2011	9138	63.2	1/19/2011	9371	72.7	2/3/2011	9321	68.9	2/18/2011	9270	61.7
12/6/2010	9298	71.4	12/21/2010	9315	70.9	1/5/2011	9066	62.3	1/20/2011	9368	72.6	2/4/2011	9363	72.2	2/19/2011	9222	61.9
12/7/2010	9308	71.3	12/22/2010	9307	71.2	1/6/2011	957	9.3	1/21/2011	9368	72.6	2/5/2011	9352	71.3	2/20/2011	9179	64.8
12/8/2010	9298	71.1	12/23/2010	9286	71.7	1/7/2011	8935	63.1	1/22/2011	9367	72.3	2/6/2011	9354	70.4	2/21/2011	9173	64.6
12/9/2010	9308	70.4	12/24/2010	9299	70.7	1/8/2011	9335	71.2	1/23/2011	9362	72.3	2/7/2011	9346	69.6	2/22/2011	9167	64.7
12/10/2010	9286	70.6	12/25/2010	7774	59.6	1/9/2011	9352	70.9	1/24/2011	9351	71.7	2/8/2011	9335	70.8	2/23/2011	9111	63.7
12/11/2010	9272	71.8	12/26/2010	9330	71.7	1/10/2011	9361	71.1	1/25/2011	9345	72.0	2/9/2011	9341	71.4	2/24/2011	9186	64.0
12/12/2010	9273	71.3	12/27/2010	9309	71.6	1/11/2011	9367	72.2	1/26/2011	9343	68.7	2/10/2011	9327	70.4	2/25/2011	9193	64.3
12/13/2010	9288	71.9	12/28/2010	9308	72.0	1/12/2011	9379	73.7	1/27/2011	9336	67.2	2/11/2011	9331	70.7	2/26/2011	9196	64.7

12/14/2010	9292	71.5	12/29/2010	9312	71.3	1/13/2011	9377	75.1	1/28/2011	9331	66.8	2/12/2011	9316	70.5	2/27/2011	9181	64.1
12/15/2010	9291	71.0	12/30/2010	9340	71.3	1/14/2011	9385	73.7	1/29/2011	9331	70.4	2/13/2011	9310	66.8	2/28/2011	9183	64.6

From above table we find that in past, turbine was run at more condensing load (72T/H) but at present above 66T/H flow of condensing steam turbine starts hunting of approx 100-200RPM. So we again check maximum design condensing flow by below curve(supplied by Manufacturer), which clearly states that we can go up to 75ton condensing load.





Current running graphs

It is clearly visible from above and below curve that after a certain condensing load this phenomenon occurs. In this case when we tried to increase the condensing load above 66T/H the speed fluctuation appeared and LP control vale started oscillating .

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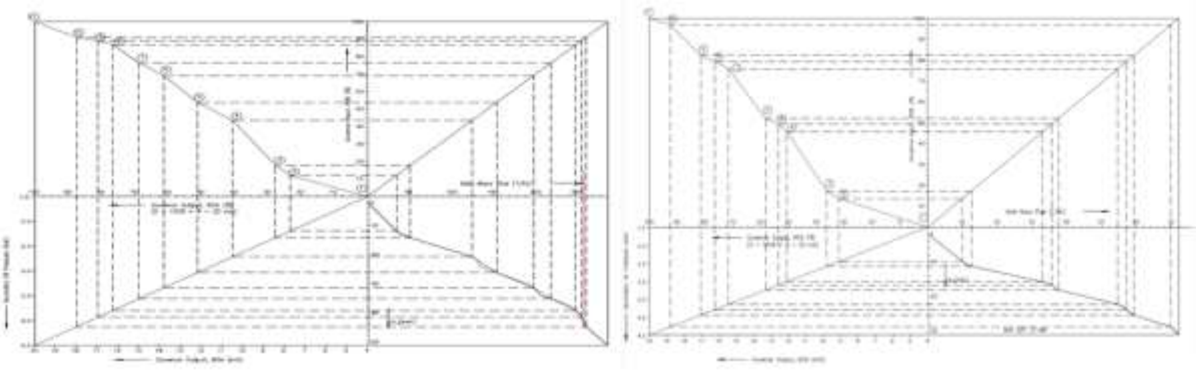
From exhaust curve we noticed that turbine was below design limit and also from HP & LP valve characteristic curve we notice that turbine governor is map up to 75T/h exhaust load.



From above we also notice that all the parameters are within range. Power of turbine and speed are directly link so we go through power calculation of turbine, Turbine is divided in to two part HP and LP from both the section power is generated. In HP section power is generated by KS steam and in LP section power is developed by HS(42kg/cm2) steam. Power ratio developed by steam in both the section *KS steam-105kg/cm2 at 550°C & HS steam-41kg/cm2 at 350°C

In HP section-ΔH of ks steam to HS steam =3359.44 KJ/kg
In LP section-ΔH of HS steam to condensing steam =3157.52 KJ/kg

So both the section of the turbine is developing same power but in HP section mass flow is 258T/H and in LP section is 65 T/H so the power in HP section is approx-3.9

In the current running condition power developed by turbine is 26 Mw from below curve as provided by manufacturer. As problem start with reduction in extraction steam so If we want to decrease extraction steam (means less KS steam flow and reduction in power of HP) flow keeping the same compressor load we have to increase the condensing load so that total power developed by both HP and LP will remain constant. Therefore in first step we checked that weather condenser is having any limitation or there is some restriction in steam flow in LP section of turbine. After condenser data sheet we found that condenser is not having any limitation also it is generating the required vacuum. So either condensing valve (LP) is not opening to allow the condensing flow or turbine is having some problem inside due to which flow of HS steam is not increasing in LP stage.

Therefore one exercise is done in the turbine, LP valve opening increased by changing the setting of LP servo motor feedback cam device. In this duration lift is increased from 28mm to 31mm on same secondary oil pressure so the valve opening inside the turbine is increased from 28mm to 31mm but no condensing load increased.

After doing this exercise it is clear that LP valve is not stuck up so there is some problem inside the turbine due to which condensing flow is not increasing more than 66T/H.

But problem is why speed hunting in decreasing the extraction steam flow, for identifying the problem we go through below steam flow Vs power curve (supplied by OEM) and draw following
Line CE- Current KS steam inlet flow
Line HF-Current extraction flow
Line IG-Extraction flow required
Point A- current operating point
Point D-Desired operating point

Restriction in condensing flow= 6 T/H (72(designed/ previously achieved)-66(existing max flow))

Reduction in power=ȠQ.h=0.6*6000/3600*3157.52 KJ/kg=3157KJ/s=3.1MW (taking turbine LP stage efficiency 60%)

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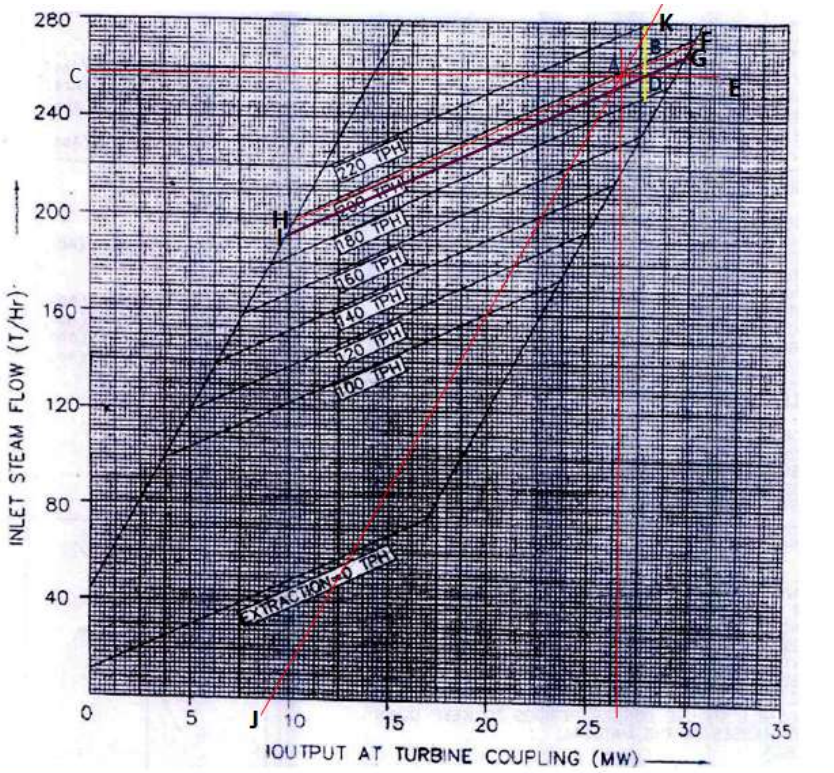
Drawing line JK for this flow reduction of 3MW which is passing from point A so if we crass point A, power will not developed by turbine and governor will not take action as per current condition first it will reduce the extraction steam but due to not developing of power by LP section, speed will drop and so it will increase KS flow for maintaining the speed but since the extraction steam is restricting by command and condensing path chocking governor was starting malfunctioning and results in speed hunting.



IV. CONCLUSION

In case of turbine Speed fluctuation there are always chances of malfunction of governor and may be due to any damage inside the governing system but not necessary, it could be due to damage inside the turbine and which finally affect in the working of governing so thorough check of running parameters must be done before inspection of any governing system.

In normal running it is taken granted that turbine may be overloaded only after developing certain defined power but by above problem, we have seen that turbine may behave same as overloaded condition in case of any steam path restriction inside the turbine occur

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