TESIS – TF 142310

ANALISA KINERJA SISTEM PENGENDALIAN PID PADA THREE PHASE SEPARATOR

DADIK PRASETYO
NRP. 2412201701

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PROGRAM MAGISTER
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DEPARTMENT OF ENGINEERINGPHYSICS
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SURABAYA
2016

Tesis ini disusun untuk memenuhi salah satu syarat memperoleh gelar

Magister Teknik (M.T.)

di

Institut Teknologi Sepuluh Nopember Surabaya

oleh:

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Tanggal Ujian : 4 Februari 2016

Periode Wisuda : September 2016

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ANALISA KINERJA SISTEM PENGENDALIAN PID PADA THREE PHASE SEPARATOR

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ABSTRAK

Separator adalah suatu sistem yang mampu memisahkan fasa minyak, fasa air dan fasa gas dari sumur (wellhead). Pada umumnya aliran yang masuk ke *three phase separator* selalu berubah sehingga level minyak selalu berubah, oleh karena itu perlu dilakukan analisa kinerja *three phase separator* untuk mengendalikan level minyak. Analisa kinerja *three phase separator* ini dilakukan dengan membuat model matematis sehingga mendekati keadaan aslinya menggunakan *separator geometry* dan perangkat lunak Matlab R2010b, maka diperlukan pengendali untuk menganalisanya, metode pengendali yang digunakan adalah metode *Ziegler-Nichols* yaitu metode kurva reaksi. Metode kurva reaksi digunakan untuk merancang tipe pengendali (P, PI dan PID) dan tuning untuk menentukan *gain* parameter pengendalinya (K_p, K_i, K_d). Berdasarkan hasil pengujian, tipe pengendalinya yang memberikan keluaran stabil adalah tipe P dengan *overshoot* 8.77% dan *settling time* 2.48 detik.

Kata kunci : *Three Phase Separator*, Model Matematis, Kurva reaksi, Separator *Geometry*, Matlab R2010b, pengendali P, PI dan PID.

ANALYSIS OF SYSTEM PERFORMANCE PID CONTROLLER ON THREE PHASE SEPARATOR

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ABSTRACT

Separator is a system that is capable of separating the oil phase, the water phase and gas phase of the wells (wellhead). In general, the flow coming into the three phase separator is always changing so that the oil level is always changing, therefore it is necessary to analyze the performance of three phase separator to control the oil level. Analysis of the performance of three phase separator is done by creating a mathematical model to approach the original state using the separator geometry and software Matlab R2010b, it is necessary to analyze the controller, the controller method used is the Ziegler-Nichols method is the reaction curve method. Reaction curve method is used to design the type of controller (P, PI and PID) and parameter tuning to determine the gain controller (Kp, Ki, Kd). Based on test results, the type of controller that provides stable output is a P-type with 8.77% overshoot and settling time of 2.48 seconds.

Keywords: Three Phase Separator, Mathematical Model, Curve reaction, Separator Geometry, Matlab R2010b, P, PI and PID controllers.

KATA PENGANTAR

Segala puji dan syukur kehadirat Alloh SWT yang telah memberikan segala rahmat serta hidayah-Nya, serta shalawat serta salam kepada junjungan Nabi Muhammad SAW, sehingga Tesis ini dapat terselesaikan dengan judul :

Analisa Kinerja Sistem Pengendalian PID pada Three Phase Separator.

Selama penyelesaian Tesis ini, penulis telah banyak mendapatkan bantuan dari semua pihak, baik secara langsung maupun tidak, secara moral maupun spiritual. Untuk itu penulis mengucapkan terima kasih kepada :

1. Agus Muhamad Hatta, ST, M.Si, PhD., selaku Ketua Jurusan Teknik Fisika, FTI-ITS Surabaya.
2. Prof. Dr. Ir. Aulia Siti Aisjah, MT., selaku pembimbing yang telah sabar membimbing dan mendampingi selama pengerjaan Tesis ini.
3. Dr. Totok Ruki Biyanto, ST. MT., yang telah memberikan pengarahan kepada penulis dalam penyusunan Tesis ini.
4. Orang tua penulis, Bapak Almarhum Bambang Soenarjo dan ibu Sri Soenarjati serta Mbak Binur Hayati dan Keluargaku (Yeni Wahyuni, M. Satriyo Wibowo dan Hanna Aulia Rahmasari) yang telah memberikan dukungan selama penyelesaian penulisan ini.
5. Seluruh Bapak dan Ibu dosen serta karyawan Jurusan Teknik Fisika, FTI-ITS Surabaya.
6. Teman-teman seangkatan S2-PJJ Jakarta (Pak Totok Haksoro, Pak Pudji, didik, Muhtadi, Husni, Tyo)
7. Teman-teman kerja yang memberikan dukungan selama penyelesaian ini (Ari Subiyanto, Emy T., Aulia M., Hafsah, Dewi, Bambang Habrianto).
8. Semua pihak yang telah turut membantu pengerjaan Tesis ini mulai awal hingga selesainya yang tidak dapat dituliskkan satu per satu di sini,

Penulis menyadari bahwa pengerjaan dan penyelesaian Tesis ini jauh dari kesempurnaan. penulis banyak mengharapkan kritik dan saran yang

membangun untuk perbaikan dan pengembangan laporan peneltian ini. Semoga laporan ini dapat bermanfaat bagi semua bidang keilmuan dan teknik.

Surabaya, Februari 2016

Penulis

DAFTAR ISI

DAFTAR GAMBAR

DAFTAR TABEL

(Halaman Ini Sengaja Dikosongkan)

DAFTAR NOTASI

Simbol

A : Luasan

$Q_{in}(t)$: *Flow* / aliran yang masuk kedalam tangki

$Q_{Out}(t)$: *Flow* / aliran yang keluar dari tangki

$Q_{om}(t)$: Aliran *fluida* minyak yang keluar dari *three phase separator*

$Q_{oa}(t)$: Aliran *fluida* air yang keluar dari *three phase separator*

$Q_{og}(t)$: Aliran *fluida* gas yang keluar dari *three phase separator*

Kp : Parameter Proporsional

Ki : Parameter Integral

Kd : Parameter Derivative

Model Parameter dan Variable

$h_O(s)$: Tinggi Minyak

$q_O(s)$: Laju aliran

l : Total Panjang Separator

$\beta(h_{Wsp})$: *Function for Cross Section Water Set Point*

k_W : *Konstanta Water Level Loop*

$\beta(h_{Osp})$: *Function for Cross Section Oil Set Point*

K : Gain total *control valve*

T_S : *Time constant control valve*

(Halaman Ini Sengaja Dikosongkan)

BAB I
PENDAHULUAN

1.1 Latar Belakang

Dalam proses pengolahan minyak terdapat *three phase* separator yang berfungsi memisahkan hidrokarbon dari sumur produksi minyak (*oil well*) menjadi fasa gas, fasa minyak dan fasa air (*produced water*) yang terpisah. Gas yang terpisah dibuang ke atmosfer melalui *HP vent header*, minyak mentah dialirkan menuju *Departing line*, sedangkan *produced water* dialirkan menuju *closed drain*. Kenyataan di lapangan aliran yang masuk ke dalam *three phase* separator dalam hal ini respon level minyak selalu berubah atau tidak konstan, dikarenakan aliran *flowrate* yang masuk berupa campuran air, minyak dan gas tidak terkontrol, sehingga diperlukan suatu analisa sistem kinerja untuk *three phase separator*. Penelitian ini bermanfaat untuk mendapatkan strategi pengendali level minyak dengan performansi pengendali yang optimal [7]. Pada sistem *three phase separator*, untuk itu dibutuhkan data pendukung dari lapangan sebagai bahan analisa.

Sistem pengendalian yang digunakan untuk *three phase separator* saat ini adalah masih manual, sehingga untuk pengukuran level ke akurasiannya kurang. Level yang akan dikendalikan adalah minyak, pengendalian level tersebut direncanakan menggunakan pengendali PID.

1.2 Perumusan Masalah

Berdasarkan latar belakang di atas, timbul permasalahan pada penelitian yang akan dilakukan, yaitu sebagai berikut:

1. Bagaimana memodelkan *three phase* pada *separator*?
2. Bagaimana merancang sistem pengendalian level minyak pada *three phase separator* dengan menggunakan Pengendali PID?

1.3 Batasan Penelitian

Adapun batasan penelitian ini adalah:

1. Batasan penelitian dalam thesis ini berkisar pada proses yang terdapat dalam *three phase* separator meliputi aliran yang masuk ke dalam separator berupa satu masukan (minyak, air dan gas) dan aliran yang keluar dari separator berupa tiga keluaran fasa.
2. Pemodelan dari sistem pengendalian *three phase* separator ini menggunakan *separator geometry*.
3. Level yang dikendalikan adalah level minyak.
4. Perancangan sistem pengendalian ini sebatas simulasi menggunakan Matlab R2010b.

1.4 Tujuan Penelitian

Tujuan dari penelitian ini adalah:

1. Membuat model matematis dari *three phase separator*.
2. Merancang sistem pengendalian level minyak pada *three phase separator* dengan menggunakan Pengendali PID.

1.5 Manfaat Penelitian

Manfaat dari penelitian ini adalah:

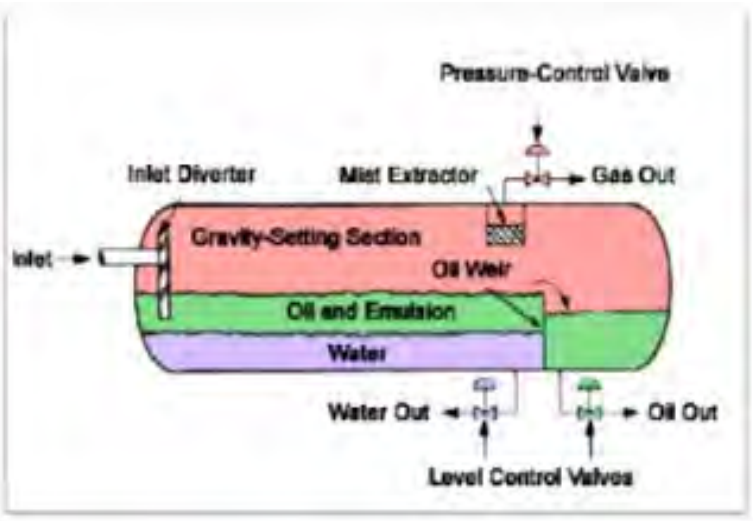
1. Dengan memodelkan *three phase separator* ini dapat membantu dalam optimisasi kinerja separator tersebut.
2. Dengan sistem pengendalian tersebut diharapkan dapat membantu dalam pengendalian level minyak.

BAB II
STUDI PUSTAKA

2.1 Separator [15]

Separator adalah tabung yang mempunyai tekanan berfungsi untuk memisahkan fluida dari sumur menjadi cairan, cairan dan gas (*three phase*) atau cairan dan gas (*two phase)*, dalam pemisahannya dapat dibagi menjadi beberapa cara yaitu :

a. Prinsip penurunan tekanan.
b. Gravity setlink
c. Turbulensi (perubahan arah) aliran
d. Pemecahan atau tumbukan fluida



Gambar 2.1 Three Phase Separator [15]

Gambar 2.1 m enunjukkan bahwa three phase separator tersebut terbagi menjadi beberapa compartement atau ruangan yang mempunyai fungsi untuk memisahkan fasa cairan (air dan minyak) dan gas, prinsip kerja separator adalah fluida yang berasal dari manifold akan masuk ke separator melalui lubang inlet dan selanjutnya menumbur inlet diverter. Disini terjadi perubahan momentum awal dalam pemisahan cairan dangas. Cairan yang berisi minyak dan air ini turun ke bagian bawah bejana separator sedangkan gasakan bergerak naik ke atas

melewati mist extractor dan keluar melalui outlet gas. Untuk air akan keluar melalui outlet air dibagian bawah sedangkan minyak akan menumpuk di bawah danmelewati weir untuk selanjutnya terakumulasi diruang khusus berisi minyak dan keluar menujuminyak outlet. Faktor utama yang berpengaruh dalam pemisahan di separator adalah berat jenis darimasing – masing fase. Dengan berat jenis yang dimiliki gas ringan, makadidalam separator letaknya akan berada di bagian atas bejana separator. Untuk air yang memiliki berat jenis paling berat diantara ketiga fase lainnya akan berada di urutan paling bawah fluida dan minyak dengan berat jenis yang lebih ringan daripada air akan akan terletak dibagian atas air. Dengan aliran fluida yang terus mengalir masuk ke dalamseparator, membuat kapasitas penampungan untuk air dan minyak akan menjadi penuh. Dengan penumpukan volume di separator akan berakibat pada tidak maksimalnya pengeluaran fase disetiap lubang outletnya. Namun bila suatu kondisi dimana tempat air terlalu sedikit maka minyak yang berada diatasnya akan keluar bersama air melalui outlet air. Untuk itu dalam penanganannya, didalam separator terdapat suatu alat level interface controlyang akanmengirimkan sinyal ke katup pembuangan air di bagian bawah, sehingga akan terbuka secara otomatis. Dengan itu, maka akan memungkinkan jumlah air yang tepat untuk dikeluarkan dari bejana sehingga antarmuka minyak dan air tetap dipertahankan pada ketinggian desain separator. Antarmuka minyak dan air adalah batas kontak langsung antara permukaan minyak dan air yang saling menimpa dibagian bawah bejana separator.

Separator mempunyai komponen pemisah sebagai berikut [15] :

1. Bagian pemisah pertama, berfungsi untuk memisahkan cairan dari aliran fluida yang masuk dengan cepat berupa tetes minyak dengan ukuran besar.
2. Bagian pengumpul cairan, berfungsi untuk memisahkan tetes cairan kecil dengan prinsip gravity setlink.
3. Bagian pemisah kedua, berfungsi untuk memisahkan tetes cairan kecil dengan prinsip gravity settlink.

4. Mist extraktor, berfungsi untuk memisahkan tetes cairan berukuran sangat kecil (kabut).
5. Peralatan kendali, berfungsi untuk mengontrol kerja separator terutama pada kondisi over pressure.

Ada dua macam proses dari pembentukan gas (vapour) dari hirokarbon cair yang bertekanan. Proses tersebut adalah *Flash separation* dan *Differential separation*. Flash separation terjadi bila tekanan pada sistem diturunkan dengan cairan dan gas tetap dalam kontak, hal mana gas tidak dipisahkan dari kontaknya dengan cairan saat penurunan tekanan yang membiarkan gas keluar dari solusinya. Proses ini menghasilkan banyak gas dan cairan sedikit. Differential separation terjadi bila gas dipisahkan dari kontaknya dari cairan pada penurunan tekanan dan membiarkan gas keluar dari solusinya. Proses ini menghasilkan banyak cairan dan sedikit gas. (sumber: Surface Facilities Training Program, Oil Handling Facilities. Medco Energi. Indonesia.hal. 27)

Suatu separator minyak/gas yang ideal, yang bertitik tolak dari pendapatan cairan yang maksimum, adalah suatu konstruksi yang dirancang sedemikian rupa, sehingga dapat menurunkan tekanan aliran *fluida* dari sumur pada *inlet* separator., menjadi atau mendekati tekanan *atmosphere* pada saluran keluar separator. Gas dipindah/dikeluarkan dari separator secara terus menerus segera setelah terpisah dari cairan, ini dikenal dengan *differential separation*, namun penataan seperti diatas tidak praktis.

Pemisahan tergantung dari efek gravitasi untuk memisahkan cairan, sebagai contoh hasil pemisahan minyak, gas dan air akan terpisah bila ditempatkan pada satu wadah karena mempunyai perbedaan densitas satu sama lainnya.
Proses pemisahan karena adanya perbedaan densitas fluida dan efek gravitasi dapat terlihat pada gambar dibawah ini:

2.1.1 Jenis Separator[15]

Dalam industri perminyakan dikenal beberapa jenis separator berdasarkan bentuk, posisinya dan fungsinya.

2.1.1.1 Jenis separator berdasarkan bentuk dan posisinya.

a. Separator tegak/vertikal.

Biasanya digunakan untuk memisahkan fluida produksi yang mempunyai kadar padatan tinggi, separator ini mudah dibersihkan serta mempunyal kapasitas cairan dan gas yang besar.

Prinsip kerja dari separator tegak / *vertical* yang car a pengoperasiannya, pengubah-arah aliran masuk (inlet diverter) akan menyebabkan cairan yang masuk menyinggung dinding separator dalam bentuk film, dan pada saat yang bersamaan memberikan gerakan centrifugal kepada fluida. Ini memberikan pengurangan momentum yang diinginkan dan mengizinkan gas untuk keluar dari film cairan. Gasnya naik ke bagian atas dari bejana, dan cairannya turun ke bawah.

Sedikit dari partikel-partikel cairan akan terbawa naik ke atas bersama gas yang naik untuk memperangkap butiran-butiran cairan yang akan ikut aliran gas digunakan mist extractor atau mist eliminator, yaitu susunan kawat kasa dan ada juga yang lebih canggih dengan ketebalan tertentu, dipasang melintang terhadap arah arus gas pada bagian atas seksi gasnya. Separator semacam ini biasa digunakan untuk tekanan kerja antara 50 sampai 150 psig.

Aplikasi Sepator ini dapat ditemui pada :

- Inlet separator in gas processing plant
- Distillation Column overhead separator

b. Separator datar /horisontal

Sangat baik untuk memisahkan fluida produksi yang mempunyai kadar padatan tinggi dan cairan berbusa. Separator ini dibedakan menjadi dua jenis, yaitu single *tube horizontal separator* dan *double tube horizontal separator*.

Prinsip kerja dari separator datar/*horizontal*, yang mana fluida mengalir secara horizontal dan bersamaan waktunya bersinggungan pada permukaan cairan. Beberapa separator mempunyai pelat-pelat penyekat (*baffle plates*) horisontal yang tersusun berdekatan dengan jarak yang sama pada hampir sepanjang bejana yang tersusun dengan kemiringan sekitar 45° terhadap bidang horisontal. Gas mengalir di dalam permukaan penyekat-penyekat dan butiran-butiran cairannya melekat pada pelat penyekat dan membentuk film yang kemudian mengalir ke seksi cairan dari separator.

Aplikasi Sepator ini dapat ditemui pada :

- Compressor knock out (KO) drum
- Inlet separator in gas processing plant

c. Separator bulat /spherical.

Separator jenis ini mempunyai kapasitas gas dan surge terbatas sehingga umumnya digunakan untuk memisahkan fluida produksi dengan kadar padatan kecil sampai sedang namun separator ini dapat bekerja pada tekanan tinggi. Terdapat dua tipe separator bulat yaitu tipe untuk pemisahan dua fasa dan tipe untuk pemisahan tiga fasa.

Aplikasi Sepator ini dapat ditemui pada :

- Inlet separator in gas processing plant

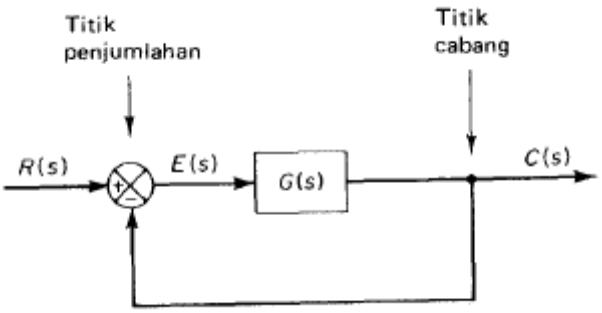
2.1.1.2 Berdasarkan fasa hasil pemisahanya jenis separator dibagi dua, yaitu:

a. Separator dua fasa, memisahkan fluida dormasi menjadi cairan dan gas, gas keluar dari atas sedangkan cairan keluar dari bawah.

b. Separator tiga fasa, memisahkan fluida formasi menjadi minyak, air dan gas. Gas keluar dari bagian atas, minyak dari tengah dan air dari bawah.

2.2 *Feedback Control System*

Feedback control atau seringkali disebut sebagai pengendalian pasca tindakan (postaction control), dilaksanakan setelah seluruh kegiatan selesai. Pengendalian ini menitikberatkan pada hasil akhir yang dicapai. Pengendalian ini memberikan umpan balik yang dapat digunakan sebagai dasar perencanaan kegiatan yang lebih baik di masa yang akan datang. Pengendalian ini juga memberikan dasar dalam pencatatan secara formal tentang pencapaian serta pengambilan keputusan dalam pengalokasian imbal jasa atas dasr kinerja (Schermerhorn:1998).

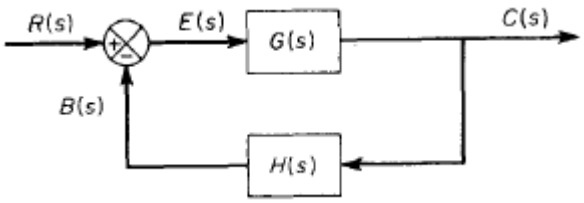


Gambar 2.2 Diagram blok sistem lup tertutup [1]

Gambar 2.2 menunjukkan suatu contoh diagram blok sistem lup tertutup. Keluaran C(s) diumpan balikkan ke titik penjumlahan untuk dibandingkan dengan masukan acuan R(s). Sifat lup tertutup dari sistem secara jelas ditunjukkan pada gambar tersebut. Keluaran blok C(s) dalam hal ini, diperoleh dengan mengalikan fungsi alih G(s) dengan masukan blok, E(s).

Setiap sistem kontrol linier dapat dinyatakan dengan suatu diagram blok yang terdiri dari beberapa blok, titik penjumlahan, dan titik cabang. Titik cabang adalah titik, tempat sinyal keluaran blok secara bersamaan menuju ke blok lain atau titik penjumlahan.

Jika keluaran duiumpan balikkan ke titik penjumlahan untuk dibandingkan dengan masukan, maka perlu pengubah bentuk sinyal keluaran agar sama dengan bentuk sinyal masukan. Sebagai contoh, dalam suatu sistem pengontrolan temperatur sinyal keluarannya biasanya adalah temperatur yang dikontrol. Sinyal keluaran tersebut, yang mempunyai dimensi temperatur, harus diubah menjadi suatu gaya atau posisi, sebelum dibandingkan dengan sinyal masukan. Pengubahan ini dilakukan oleh elemen umpan balik yang mempunyai fungsi alih H(s), seperti ditunjukkan pada gambar 2.9. Peranan penting lainnya dari elemen umpan balik adalah memodifikasi keluaran sebelum dibandingkan dengan masukan. Pada contoh ini, sinyal umpan balik yang diumpan balikkan ke titik penjumlahan untuk dibandingkan dengan sinyal masukan adalah B(s)=H(s)C(s).



Gambar 2.3 Sistem lup tertutup [1]

Untuk sistem yang ditunjukkan pada gambar 2.3 keluaran C(s) dan masukan R(s) direlasikan sebagai berikut:

$$C(s)=G(s)E(s) \quad \text{... (2.1)}$$

$$E(s)=R(s)-B(s)$$

$$=R(s)-H(s)C(s) \quad \text{... (2.2)}$$

Eliminasi E(s) dari persamaan-persamaan ini memberikan

$$C(s)=G(s)[R(s)-H(s)C(s)] \quad \text{... (2.3)}$$

atau,

$$\frac{C(s)}{R(s)}=\frac{G(s)}{1+G(s)H(s)} \quad \text{... (2.4)}$$

Fungsi alih yang merealisasikan C(s) dengan R(s) disebut fungsi alih lup tertutup. Fungsi alih ini merealisasikan dinamika sistem lup tertutup dengan dinamika elemen umpan maju dan elemen umpan balik.

Dari persamaan 2.4, C(s) diberikan oleh

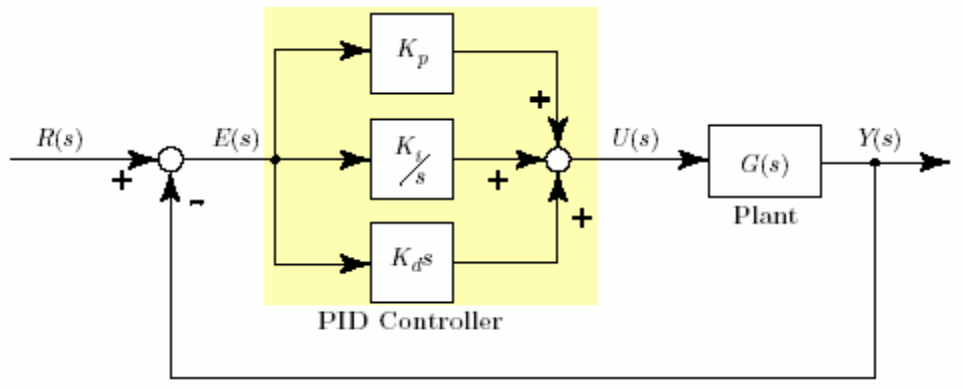
$$C(s)=\frac{G(s)}{1+G(s)H(s)}R(s) \quad \text{... (2.5)}$$

2.3 Pengendali PID [1]

PID adalah merupakan pengendali yang sering digunakan untuk bidang *automation* di industri, dikarenakan alasan flexibilitas dari kontroler ini memberikan penanganan pengendalian pada proses di industri. Pengendalian disini ada tiga macam pengendali atau kontroler yang sering digunakan, yaitu proporsional, integral dan derivatif. Dengan R(s) adalah masukan kendali dan Y(s) adalah keluarannya. Pengendali PID (Proporsional+Integral+Diferensial) adalah merupakan gabungan dari tiga jenis kontroler, yaitu kontroler tipe P (*Proportional*), tipe I (*Integral*) dan tipe D (*Defferential*). Jika masing-masing dari ketiga kontroler tersebut berdiri sendiri-sendiri akan memberikan aksi kontrol yang kurang bagus. Karena selain sifat ketiga kontroler tersebut saling bebas ketiganya juga saling mempunyai kelemahan dan kelebihan. Dengan mengkombinasikan ketiga jenis kontroler tersebut ke dalam satu kontroler diharapkan akan mampu memberikan performansi sistem sesuai yang diinginkan

Hukum dari Pengendali PID yaitu,

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{d}{dt} e(t) \quad \text{... (2.6)}$$



Gambar 2.4 Pengendali PID [1]

Persamaan dinamik kontroler PID dapat diberikan sebagai berikut :

$$u(t) = u_P(t) + u_I(t) + u_D(t) \quad \text{... (2.7)}$$

$$u(t) = K_P.e(t) + \frac{K_P}{\tau_i} \int e(t)dt + K_P.\tau_d.\frac{d}{dt} e(t) \quad \text{... (2.8)}$$

$$U(s) = K_P.E(s) + \frac{K_P}{s.\tau_i} \cdot E(s) + K_P.\tau_d.s.E(s) \quad \text{... (2.9)}$$

$$U(s) = K_P.E(s)\left(1 + \frac{1}{s.\tau_i} + s.\tau_d\right) \quad \text{... (2.10)}$$

$$\frac{U(s)}{E(s)} = K_P + \frac{K_I}{s} + K_D.s \quad \text{... (2.11)}$$

dimana :

K_P : konstanta proporsional

$K_I = \frac{K_P}{\tau_i}$: konstanta integral

$K_D = K_P.\tau_d$: konstanta diferensial

Kontroler proporsional (*Kp*) memberikan efek mengurangi waktu naik, tetapi tidak menghapus kesalahan keadaan tunak, kontroler integral (*Ki*) akan memberi efek menghapus keadaan tunak, tetapi berakibat memburuknya respons *transient*, kontroler diferensial (*Kd*) akan memberikan efek meningkatkan stabilitas sistem, mengurangi *overshoot*, dan menaikkan respons *transient*. Efek dari setiap kontroler (*Kp, Ki* dan *Kd*) dalam sistem loop tertutup diperlihatkan pada tabel 2.1.

Respons loop tertutup	**Waktu naik**	**Overshoot**	**Settling time**	**Kesalahan keadaan tunak**
K_P	Menurun	Meningkat	Perubahan kecil	Menurun
K_I	Menurun	Meningkat	Meningkat	Hilang
K_D	Perubahan kecil	Menurun	Menurun	Perubahan kecil

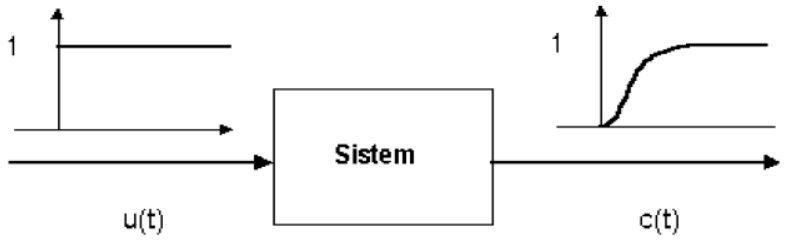
Tabel 2.1 Pengaruh kontroler (*Kp, Ki* dan *Kd*) dalam sistem loop tertutup[1]

2.4 Tuning Pengendali PID [1]

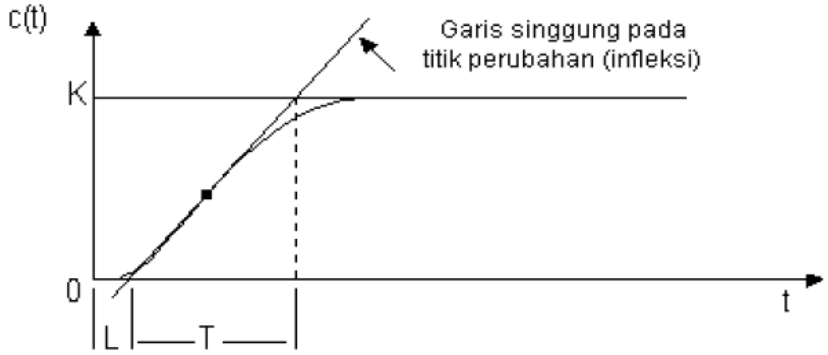
Banyak peneliti yang telah mencoba berbagai metode tuning kontroler PID, mulai dari *trial and error method*, metode *Ziegler-Nichols*, metode Cohen-Coon, metode Astrom-Hagglund dan sebagainya.

2.4.1 Metode Kurva Reaksi

Metode ini didasarkan terhadap reaksi sistem untaian terbuka. *Plant* sebagai untaian terbuka diberi sinyal fungsi tangga satuan (Gambar 2.5). Kalau *plant* minimal tidak mengandung unsur integrator ataupun *pole-pole* kompleks, reaksi sistem akan berbentuk S. Gambar 2.6 menunjukkan kurva berbentuk S tersebut. Kelemahan metode ini terletak pada ketidakmampuannya untuk *plant* integrator maupun *plant* yang memiliki *pole-pole* kompleks.



Gambar 2.5 Metode Kurva Reaksi[1]



Gambar 2.6 Kurva berbentuk S[1]

Kurva berbentuk S mempunyai dua konstanta, waktu mati (*dead time*) L dan waktu tunda T. Dari Gambar 2.6 terlihat bahwa kurva reaksi berubah naik, setelah selang waktu L. Sedangkan waktu tunda menggambarkan perubahan kurva setelah mencapai 66 % dari keadaan mantapnya. Pada kurva dibuat suatu garis yang bersinggungan dengan garis kurva. Garis singgung itu akan memotong dengan sumbu absis dan garis maksimum. Perpotongan garis singgung dengan sumbu absis merupakan ukuran waktu mati, dan perpotongan dengan garis maksimum merupakan waktu tunda yang diukur dari titik waktu L. *Tuning* parameter PID didasarkan perolehan kedua konstanta itu. Tabel 2.2 merupakan rumusan *tuning* parameter PID berdasarkan cara kurva reaksi.

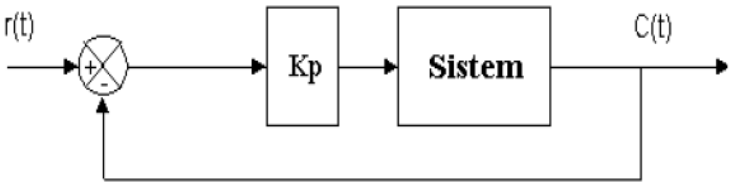
2.4.2 Metode Osilasi

Metode ini didasarkan pada reaksi sistem untaian tertutup. *Plant* disusun serial dengan kontroler PID. Semula parameter parameter integrator di-*setting* tak

berhingga dan parameter diferensial di-*setting* nol ($T_i = \sim ; T_d = 0$). Parameter proporsional kemudian dinaikkan bertahap. Mulai dari nol sampai mencapai harga yang mengakibatkan reaksi sistem berosilasi. Reaksi sistem harus berosilasi dengan amplitudo tetap (*sustained oscillation*). Gambar 2.7 menunjukkan rangkaian untaian tertutup pada cara osilasi.

Tipe kontroler	$\mathbf{K_P}$	$\mathbf{T_I}$	$\mathbf{T_D}$
P	$\frac{T}{KL}$	-	-
PI	$0.9\frac{T}{KL}$	$3L$	-
PID	$1{,}2\frac{T}{KL}$	$2L$	$0{,}5L$

Tabel 2.2 Rumusan tuning dengan metode kurva reaksi[1]



Gambar 2.7 Metode Osilasi[1]

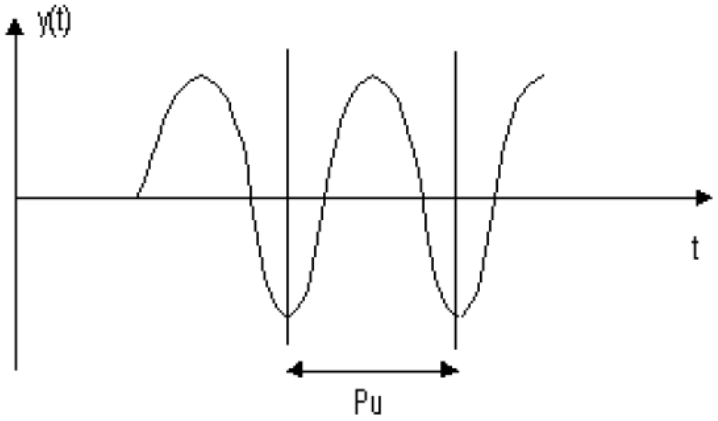
Nilai penguatan proportional pada saat sistem mencapai kondisi *sustain oscillation* disebut *ultimate gain* K_u. Periode dari *sustained oscillation* disebut *ultimate period* P_u (Perdikaris, 1991, 43 3). Gambar 2.7 menggambarkan kurva reaksi untaian tertutup ketika berosilasi.

Tuning parameter PID didasarkan terhadap kedua konstanta hasil eksperimen, K_u dan P_u. Ziegler dan Nichols menyarankan penyetelan nilai parameter *Kp, Ki* dan *Kd* berdasarkan rumus yang diperlihatkan pada Tabel 2.3.

Sifat dari pengendali P yang selalu meningkatkan *offset*, dapat ditutupi oleh pengendali I, sedangkan untuk pengendali D dapat lebih mempercepat reaksi sistem sehingga pengendali PID menghasilkan respons yang lebih cepat dari pengendali integral dan mampu menghilangkan *offset* yang ditinggalkan oleh pengendali proporsional seperti yang ditunjukkan pada gambar 2.8.

Tipe kontroler	$\mathbf{K_P}$	$\mathbf{T_I}$	$\mathbf{T_D}$
P	$0{,}5Ku$	0	0
PI	$0{,}45Ku$	$\frac{Pu}{1{,}2}$	0
PID	$0{,}6Ku$	$\frac{Pu}{2}$	$\frac{Pu}{8}$

Tabel 2.3 Rumusan tuning dengan metode osilasi [1]



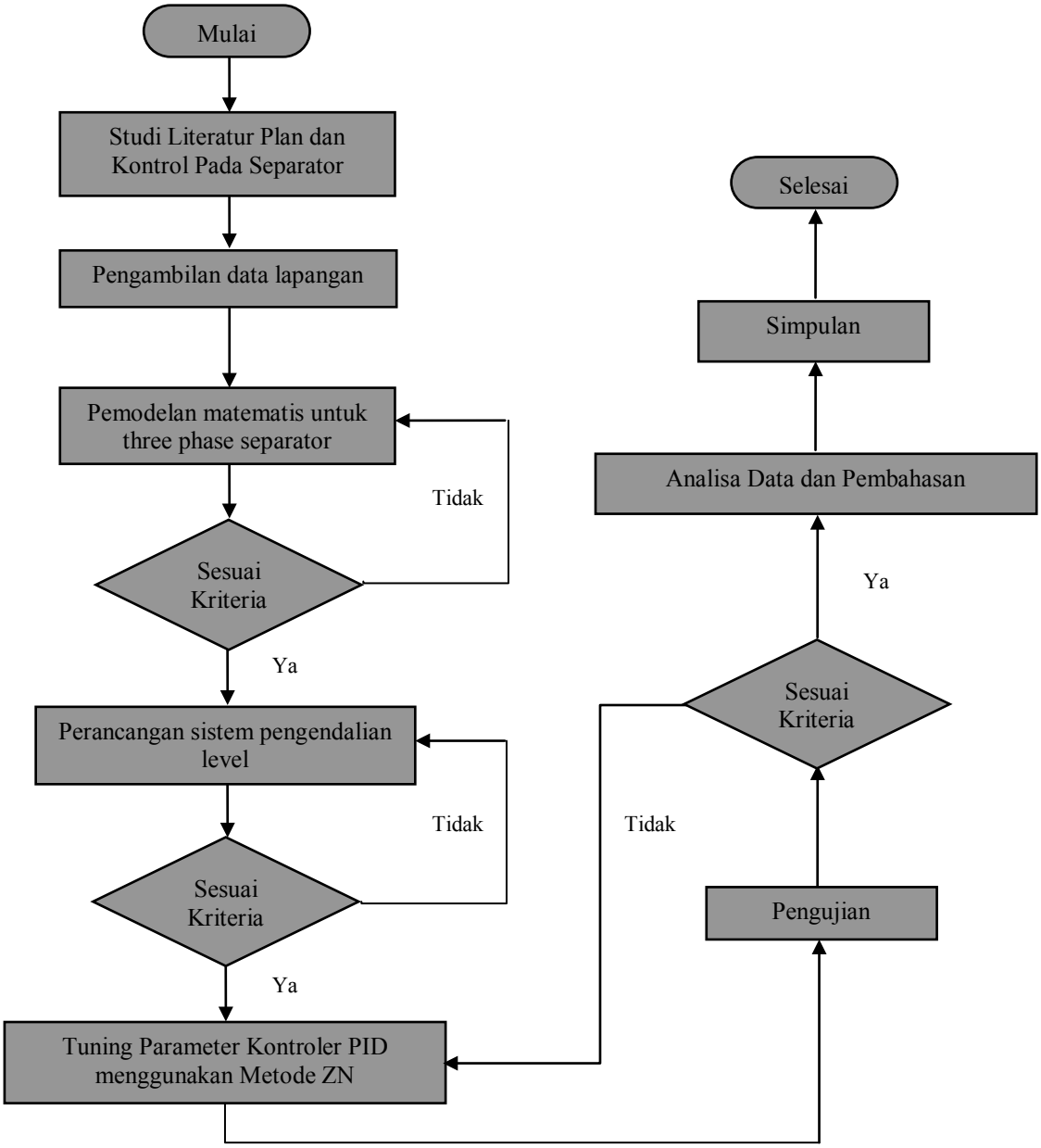
Gambar 2.8 Kondisi *sustain oscillation* pada metode osilasi[1]

(Halaman Ini Sengaja Dikosongkan)

BAB III
METODOLOGI PENELITIAN

3.1 Diagram Alir

Pembahasan pada bab ini adalah mengenai tahapan pemodelan dan sistem kontrol pada separator. Secara umum alur penelitian dapat dilihat pada gambar 3.1 dibawah ini.

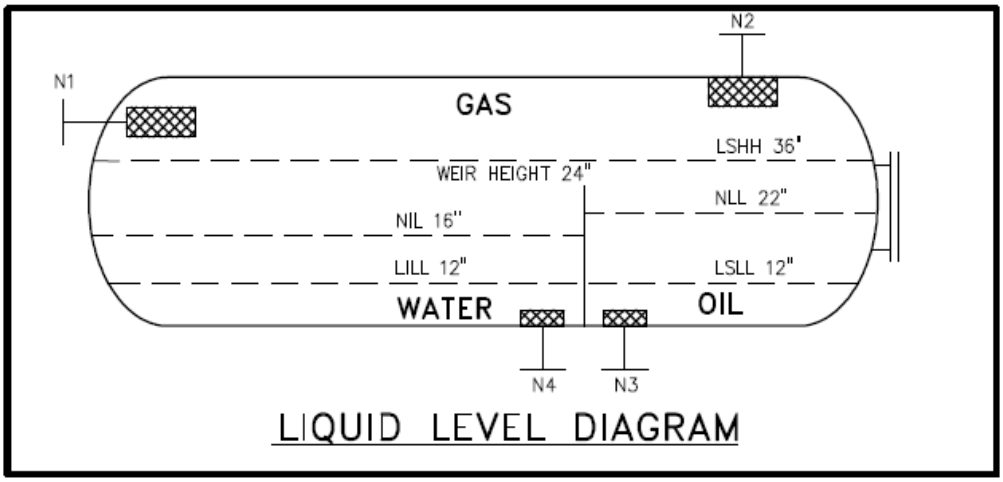


Gambar 3.1 Diagram Alir

3.2 Studi Literatur

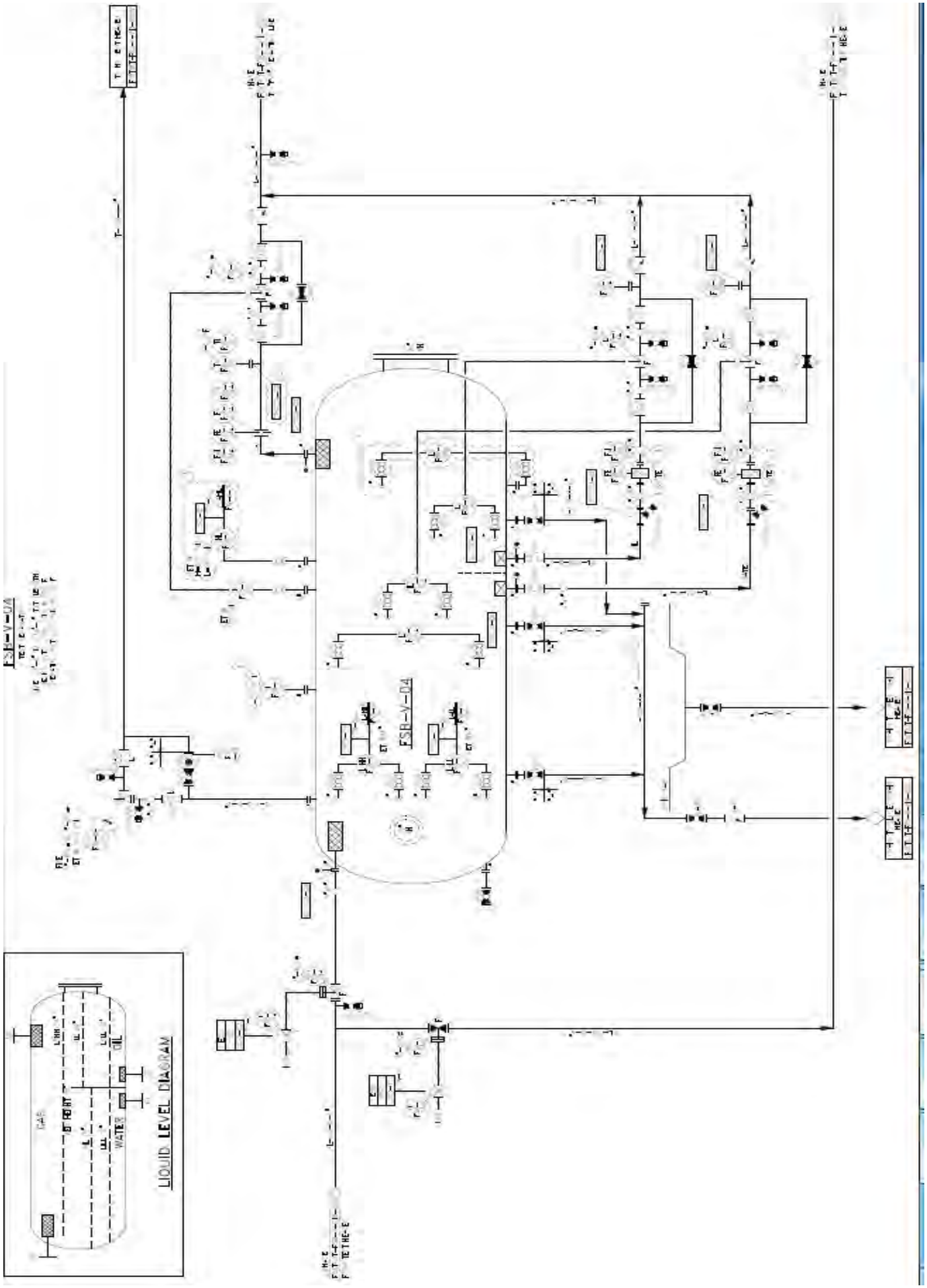
Tahapan awal dari penelitian ini adalah mencari bahan-bahan penelitian dengan memilih *journal, article, proceedings, report, websites,* dan beberapa buku sebagai acuan atau *reference*.

Data dari literatur bisa berupa P&ID seperti pada gambar halaman 19, menerangkan bahwa masukan (*pressure, flow, temperature*) berasal dari *test header* berupa 3 *phase*, yaitu gas, oil, and water dengan menggunakan pipa 4". Kemudian masukan tersebut dipisahkan menggunakan *three phase separator* untuk mengurangi adanya *slug* atau material yang tidak diperlukan. *Slug* atau kotoran (*oil* dan *water*) tersebut selanjutnya dibuang ke *drain* (*open* dan *closed*), sedangkan untuk gas, apabila terjadi tekanan berlebih dan dibuang ke HP *vent header*.



Gambar 3.2 Liquid Level Diagram *Three Phase Horizontal Separator*

Dari gambar 3.2 menjelaskan bahwa separator ini mempunyai 2 compartment (2 ruangan) dengan *weir* dan terdapat desain untuk level. Ruangan pertama berisi *liquid* (air dan minyak) dan gas, *three phase separator* ini mempunya *alarm setting* yaitu untuk LSLL = 12", NLL = 22", dan LSHH = 36" pada ruangan untuk minyak.



Gambar 3.3 P&ID dari *three phase separator*

3.3 Spesifikasi dari *Three Phase Separator*

Three phase separator ini mempunyai spesifikasi seperti tabel dibawah ini:

Deskripsi	*Horizontal, three phase separator*
Standard Kode	• *ASME VIII Div 1* • *NACE M R-01-75* • *DNV 2.7-1*
ANSI	#600
Ukuran	*4'-8" ID x 13'-0" T/T (Lenght)*
Desain P / T	*1030 Psig / 200^{0}F*
Operating P / T	*155 Psig / 116^{0}F*
Fluid inlet *Fluid outlet-Gas* *Fluid outlet-Oil* *Fluid outlet-Water* *Fluid outlet-Vent*	*6 in ANSI #600 RF Flange* *4 in ANSI #600 RF Flange* *2 in ANSI #600 RF Flange* *2 in ANSI #600 RF Flange* *2 in ANSI #600 RF Flange*
Liquid sampling points	• *2 in ANSI #600 RF Flange outlet oil line* • *1 in ANSI #600 RF Flange outlet water line*
Gas measurement equipment *Oil measurement equipment* *Water measurement equipment*	*4 in Orifice meter* *3/4 in Turbine meter* *3/4 in Turbine meter*
Vessel pressure control equipment on gas line *Oil level control equipment on oil line* *Water level control equipment on water line*	*2 in Fail Open Pneumatic Pressure Control Valve d engan Pressure Controller* *1 in Fail Closed Pneumatic Level Control Valve dengan Level Controller* *1 in Fail Closed Pneumatic Level Control Valve dengan Level Controller*

Safety Devices	*1 in ANSI #600 x 2 in ANSI #150 pilot operated pressure safety valves mounted directly on independent vessel nozzels with 2 in. vent line to base skid edge*
Vessel Manway	*20-in. diameter, ANSI 600RF flange, located at rear of vessel*

Tabel 3.1 Spesifikasi dari *Three phase separator*

Di bawah ini adalah Tabel 3.2 data parameter proses dan Table 3.3 data dimensi *three phase separator*.

PARAMETER PROSES	**NILAI PROSES**
Q_{in}	1119.895 bbl/day
Q_{om}	430.282 bbl/day
Q_{oa}	26.68 bbl/day
P_1	278.5 psig
P_2	279.425 psig
SG_m	0.825
Cv_m	104
T	110.465 ^{0}F
h_m	14 inch

Tabel 3.1 Data Parameter Proses

DIMENSI	**NILAI**
l	19 ft
D	56 inch
LSHH	36 inch
NLL	22 inch
LSLL	12 inch

Tabel 3.2 Data Dimensi *Three Phase Separator*

3.4 Pemodelan Matematis *Three Phase Separator*

Dalam hukum kesetimbangan, sistem tangki *three phase separator* dapat didekati dengan:

Rate of volumetric – Rate of volumetric = Accumulation into the tank out of the tank volumetric in the tank

Atau secara matematis dapat dimodelkan sebagai berikut:

$$A\frac{dh}{dt} = Q_{in}(t) - Q_{Out}(t) \qquad \text{... 3.1}$$

Dimana:

$A\frac{dh}{dt}$: Dinamika volume yang terakumulasi dalam tangki

$Q_{in}(t)$: *Flow* / aliran yang masuk kedalam tangki

$Q_{Out}(t)$: *Flow* / aliran yang keluar dari tangki

Fluida yang keluar dari *three phase separator* ini terdiri dari minyak, air dan gas. Persamaan (3.1) dapat dikembangkan menjadi persamaan dinamika *level* menjadi persamaan (3.2), yaitu:

$$A\frac{dh}{dt} = Q_{in}(t) - Q_{om}(t) - Q_{oa}(t) - Q_{og}(t) \qquad \text{... 3.2}$$

Dimana,

$Q_{om}(t)$: Aliran *fluida* minyak yang keluar dari *three phase separator*

$Q_{oa}(t)$: Aliran *fluida* air yang keluar dari *three phase separator*

$Q_{og}(t)$: Aliran *fluida* gas yang keluar dari *three phase separator*

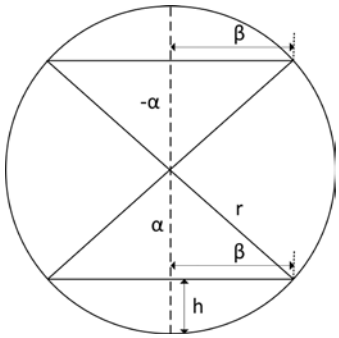
Pendekatan model matematis *three phase separator* tersebut dengan asumsi, bahwa :

1. Pendekatan bangun *three phase separator* ini di dekati dengan bangun kotak atau balok.
2. Tekanan dan suhu dianggap konstan.
3. Level air dan pada three phase separator ini tidak dikendalikan.

Dalam *Control Structure and T uning Method Design for suppressing Disturbances in a multi-phase Separator* (Mathias Wilhemsen-2013) Pemodelan *three phase separator* ini didasarkan oleh bentuk geometris *separator*.

Pada gambar 3.4 m enunjukkan bahwa cara menentukan *liquid level* dihitung. Persamaan untuk menghitung cairan penampang dan perhitungan daerah dari potongan lingkaran. Jari-jari silinder diberikan oleh r = $\frac{d}{2}$

Kita mengetahui bahwa perubahan permukaan *liquid* adalah sebagai fungsi dari *liquid level*. Lebar permukaan cairan dapat dihitung dengan persamaan *Pythagoras* diberikan oleh Persamaan (3.3). Setengah lebar dilambangkan dengan β, *radius* oleh r, tinggi cairan oleh h dan ruang antara tinggi cairan dan tengah tangki oleh α (Kristensen 2008). Gambar 3.4 menunjukkan gambar penampang *separator* menunjukkan parameter yang akan dipakai untuk perhitungan.



Gambar 3.4 *Cross-section* dari *Three Phase Horizontal Separator*[19]

$$r^2 = \propto^2 + \beta^2 \quad \text{... 3.3}$$

$$\beta^2 = r^2 - \alpha^2$$

$$\beta = \sqrt{r^2 - \alpha^2} \quad \text{... 3.4}$$

Persamaan 3.4, ∝ diganti dengan r – h untuk mendapatkan nilai β sebagai sebuah fungsi dari h seperti ditunjukkan pada persamaan 3.5. dan 3.6.

$$\beta(h) = \sqrt{r^2 - (r-h)^2} \quad \text{... 3.5}$$

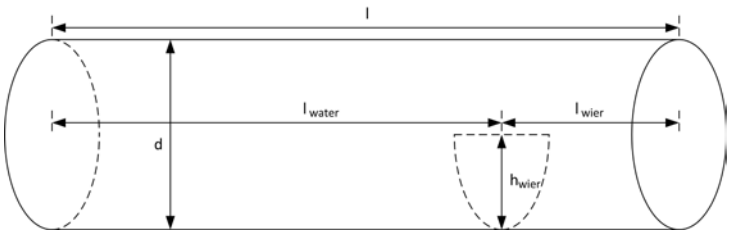
$$\beta(h) = \sqrt{2rh - h^2} \quad \text{... 3.6}$$

Ada beberapa permasalahan ketika tinggi cairan naik di atas titik tengah *separator*. Dalam kasus tertentu α akan negatif yang mana tidak biasa dipakai dalam perhitungan. Namun hal ini dapat diselesaikan dengan pertimbangan simetris. Dengan rumus untuk lebar permukaan cairan, kita dapat menemukan area penampang. Hal ini ditemukan dengan cara mengintegrasikan segmen garis dari *separator* bawah h = 0 ke tinggi cairan. Luas penampang cairan disebut A(h).

Maka didapat,

$$A(h) = 2\int_0^h \sqrt{2rh - h^2 dh'}$$

$$A(h) = 2\int_0^h \beta(h')dh' \qquad \text{... 3.7}$$



Gambar 3.5 Dimensi dari *three phase separator*[19]

Untuk menentukan volume cairan, daerah luas penampang dikalikan dengan panjang (l) dari daerah didedikasikan untuk setiap cairan. Perhitungan dari Persamaan (3.8) menunjukkan turunan dari volume. Konstruksi tangki dan dimensi untuk perhitungan volume yang ditunjukkan pada Gambar 3.5.

$$V(h) = 2l\int_0^h \beta(h')dh' \qquad \text{... 3.8}$$

$$\frac{dV}{dt} = \frac{d}{dt}2\int_0^h \beta(h')dh'$$

$$\frac{dV}{dt} = 2l\frac{\partial}{\partial h}\left(\int_0^h \beta(h')dh'\right)\frac{\partial h}{\partial t}$$

$$\frac{dV}{dt} = 2l(\beta(\mathrm{h}) - \beta(0))\frac{\partial h}{\partial t}$$

Untuk perbedaan kecil ketinggian cairan di tengah tangki, lebar permukaan cairan hanya akan membuat perubahan kecil. Artinya bahwa untuk tingkat perubahan kecil pada *separator* dapat diasumsikan memiliki dinding polos.

Sekarang ini akan memodelkan level minyak dengan mempertimbangkan level minyak relatif h_o ke h_w permukaan air. Pertama volume minyak yang tersedia berasal di separator.

Dari Gambar 3.1 dan Gambar 3.5 kita melihat bahwa volume minyak dibagi menjadi tiga bagian yang diberikan dalam persamaan matematika (3.8). Ruang antara permukaan air dan atas wier memiliki panjang (l_w). Dari atas wier ke permukaan minyak memiliki panjang (l) dan belakang wier dari separator bawah ke atas wier memiliki panjang ($l - l_w$). Di model kami tinggi minyak tidak boleh di bawah puncak wier. Itu berarti minyak yang di ruang bawah wier dan di sisi outflow dapat dianggap sebagai volume konstan. Hal ini diketahui bahwa tinggi minyak tergantung dari tinggit air.

Maka,

$$V_O(h_W, h_O) = V(h_W) + V(h_O) + V_{Wier} \quad \text{... 3.9}$$

$$\frac{dV_O(h_W, h_O)}{dt} = \frac{\partial V_O}{\partial h_W} \cdot \frac{dh_W}{dt} + \frac{\partial V_O}{\partial h_O} \cdot \frac{dh_O}{dt}$$

$$\frac{dV_O(h_W, h_O)}{dt} = \frac{\partial V_{O1}}{\partial h_W} \cdot \frac{dh_W}{dt} + \frac{\partial V_{O2}}{\partial h_O} \cdot \frac{dh_O}{dt}$$

Volume dari minyak terbagi menjadi dua yaitu volume bawah wier adalah V_{O1} dan diatas wier adalah V_{O2}.

Maka,

$$V_{O1} = 2l_W \cdot \int_{h_W}^{h_{Wier}} \beta(h')dh'$$

$$\frac{\partial V_{O1}}{\partial h_W} = 2l_W \cdot \frac{\partial}{\partial h_W}(\beta(h_{Wier}) - \beta(h_W))$$

$$\frac{\partial V_{O1}}{\partial h_W} = 2l_W \cdot (-\beta(h_W)) \quad \text{... 3.10}$$

$$V_{O2} = 2l \cdot \int_{h_{Wier}}^{h_O} \beta(h')dh'$$

$$\frac{\partial V_{O2}}{\partial h_O} = 2l \cdot \frac{\partial}{\partial h_O}(\beta(h_O) - \beta(h_{Wier}))$$

$$\frac{\partial V_{O2}}{\partial h_O} = 2l \cdot \beta(h_O) \quad \text{... 3.11}$$

Perubahan tinggi minyak berasal dari neraca massa diberikan dalam Persamaan (3.12). Flassing dilambangkan sebagai Z_O.

$$\frac{dm_O}{dt} = W_{i_O}(t) - W_{O_O}(t) - Z_O \qquad \text{... 3.12}$$

$$\frac{dV_O}{dt}\rho_O = \rho_O\left(q_{i_O}(t) - q_{O_O}(t)\right) - Z_O$$

Density dari minyak ρ diasumsikan konstan dan karena itu kita dapat melakukan sisa perhitungan untuk aliran volume. *Flassing* Z_O tidak dianggap dalam analisis dan tidak digunakan untuk perhitungan. Aliran net oil disebut q_O (t) dan $q_{i_O}(t) - q_{O_O}(t)$.

Volume minyak diberikan dalam Persamaan (3.10) dan Persamaan (3.11) disatukan dengan massa keseimbangan, mengarah ke model untuk perubahan tinggi minyak diberikan dalam Persamaan (3.13).

$$\frac{dV_O}{dt} = \left(q_{i_O}(t) - q_{O_O}(t)\right)$$

$$\frac{\partial V_{O1}}{\partial h_W}.\frac{dh_W}{dt} + \frac{\partial V_{O2}}{\partial h_O}.\frac{dh_O}{dt} = \left(q_{i_O}(t) - q_{O_O}(t)\right)$$

$$\frac{\partial V_{O2}}{\partial h_O}.\frac{dh_O}{dt} = \left(q_{i_O}(t) - q_{O_O}(t)\right) - \frac{\partial V_{O1}}{\partial h_W}.\frac{dh_W}{dt}$$

$$\frac{dh_O}{dt} = \frac{\left(q_{i_O}(t) - q_{O_O}(t)\right) - \frac{\partial V_{O1}}{\partial h_W}.\frac{dh_W}{dt}}{\frac{\partial V_{O2}}{\partial h_O}} \qquad \text{... 3.13}$$

Dengan mengubah sistem ke dalam domain frekuensi untuk menganalisa kenaikan cairan. Dalam membuat fungsi transfer kita harus membuat sistem linier yang diberikan dalam persamaan (3.13), di sekitar titik kerja. Untuk mempermudah tinggi air diasumsikan konstan dengan besarnya k_w pada titik kerja ketika analisa dilakukan. Persamaan (3.14) menunjukkan model tinggi minyak linear dalam domain waktu.

Didapat,

$$h_O(s) = \frac{q_O(S) - (\beta(h_{Wsp}).k_W)}{2l\left(\beta(h_{Osp})\right)S} \qquad \text{... 3.14}$$

Dimana,

$h_O(s)$: Tinggi Minyak

$q_O(s)$: Laju aliran $(q_{in} - q_{oa} - q_{om})$

l : Total Panjang Separator : 3.96 m

$\beta(h_{Wsp})$: *Function for Cross Section Water Set Point* : 0.421

k_W : *Konstanta Water Level Loop* : $3.8\text{x}10^{-3}$

$\beta(h_{Osp})$: *Function for Cross Section Oil Set Point* : 0.421

Berdasarkan nilai parameter tersebut di atas persamaan (3.14) dapat dituliskan dalam bentuk persamaan (3.15), Maka didapat persamaan (3.15) dengan menggunakan parameter yang ada,

$$h_O(s) = \frac{q_O(S) - (1.6x10^{-3})}{3.33S} \quad \text{...3.15}$$

$$q_O(S) = q_{in} - q_{oa} - q_{om}$$
$$= 1119.895 - 26.68 - 430.282$$
$$= 662.933 \text{ bbl/day}$$

Maka persamaan 3.16 berubah menjadi,

$$h_O(s) = \frac{662.933 - (1.6x10^{-3})}{3.33S} \quad \text{... 3.16}$$

3.5 Pemodelan Aktuator

Dalam pengendalian level ini diperlukan *control valve* untuk mengatur laju aliran fluida dari three phase separator menuju ke FSB Departing Line. Model Matematis dari *control valve* adalah sebagai berikut:

$$\frac{M_S}{U} = \frac{K}{T_S + 1} \quad \text{...3.14}$$

Dimana,

K : Gain total *control valve* : (15-3) psi

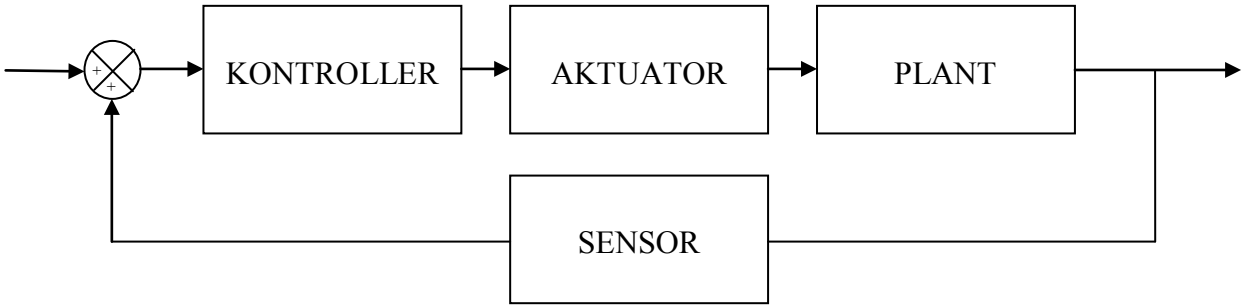
T_S : *Time constant control valve* : 0.34 detik (*Valve type* A T-63)[3]

Maka,

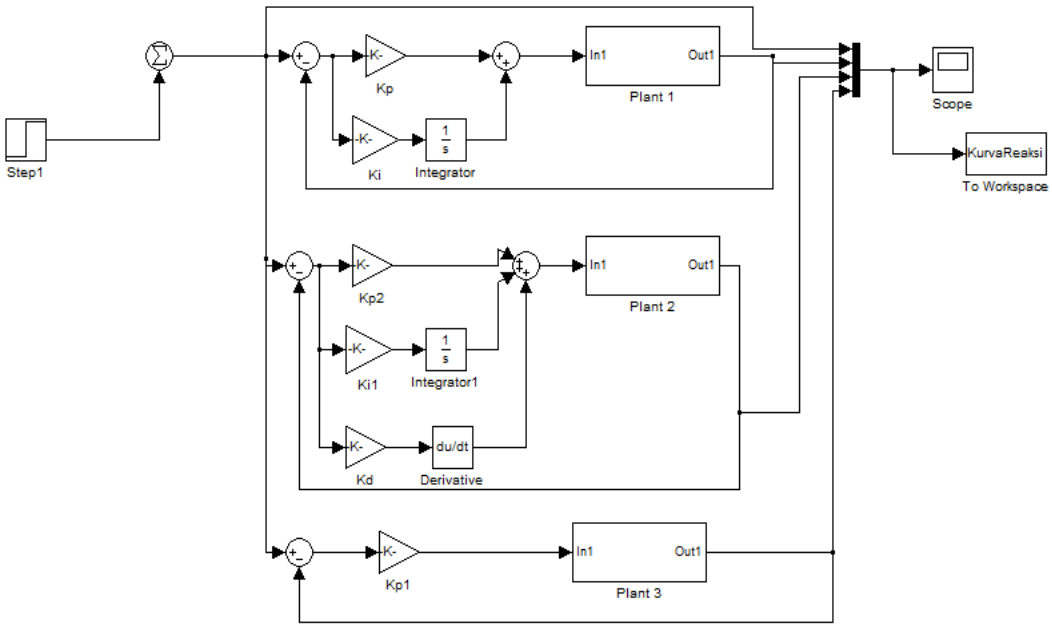
$$\frac{M_S}{U} = \frac{12}{0.34S + 1}$$

3.6 Blok Diagram Sistem Pengendalian

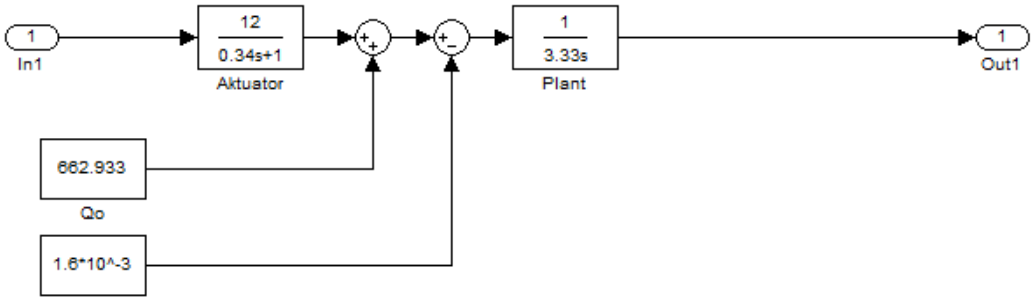
Blok diagram dari sistem pengendalian ini dapat dilihat dibawah ini,



Gambar 3.6 Blok diagram sistem pengendalian pada *three phase separator*

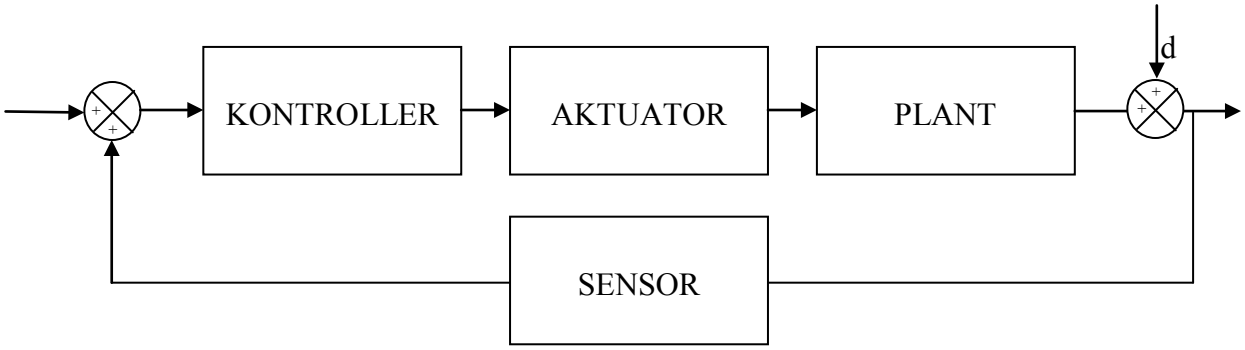


Gambar 3.7 Blok diagram dari sistem pengendalian pada *three phase separator (simulink)*

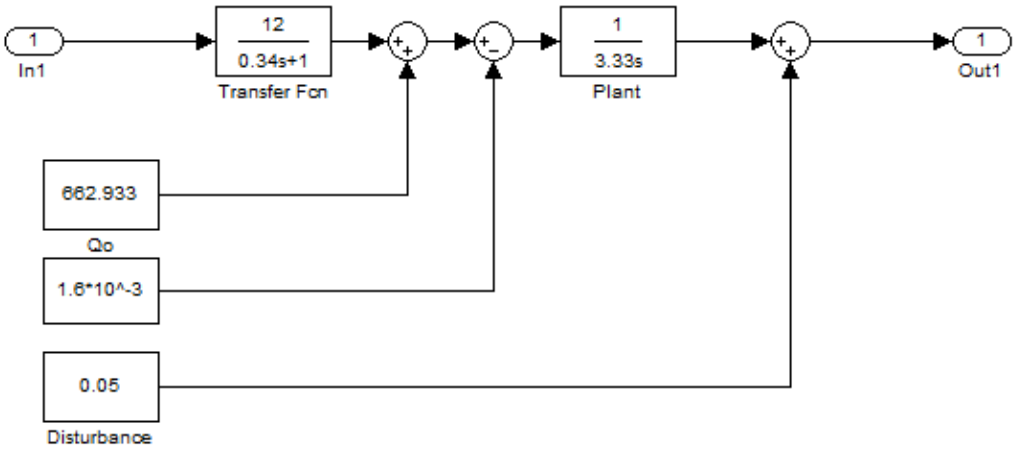


Gambar 3.8 Blok Diagram dari Plant sistem *three phase separator (simulink)*

Gambar 3.6 menunjukkan blok diagram dari pengendalian *three phase separator*, dari gambar tersebut dapat diuraikan dengan menggunakan fasilitas yang ada dalam Matlab R2010b yaitu *simulink*, akan diuraikan menjadi gambar 3.7 dan 3.8, be gitu juga dengan gambar 3.9 da n 3.10, pe rbedaannya adalah gambar 3.9 da n 3.10 d itambahkan *disturbance*/gangguan sebesar 5%. Hasil dari analisa tersebut dapat dilihat pada bab 4.



Gambar 3.9 Blok diagram sistem pengendalian pada sistem *three phase separator* dengan gangguan



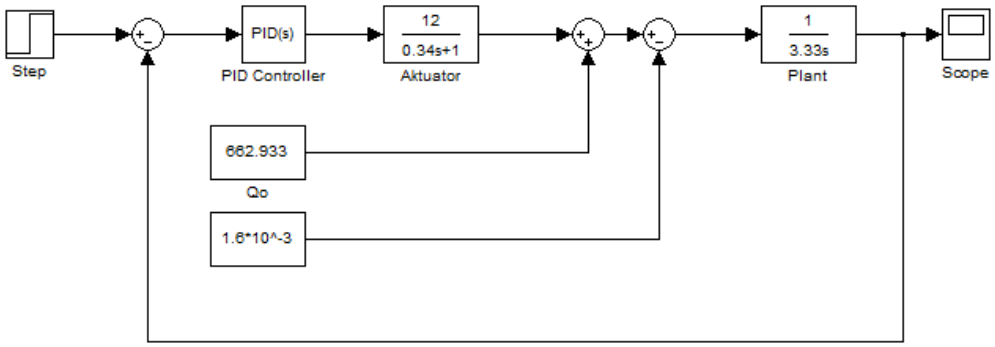
Gambar 3.10 Blok diagram dari Plant sistem *three phase separator* dengan gangguan 5% (simulink)

3.7 Tuning pada Pengendali PID

Setelah blok diagram di jalankan dengan menggunakan bantuan Matlab R2010b dengan memasukkan model matematis dan parameter lainnya, maka

langkah selanjutnya adalah melakukan tuning dari Pengendali PID. Metode yang digunakan dalam melakukan tuning ini adalah menggunakan metode *Ziegler-Nichols* dengan cara kurva reaksi. Untuk lebih memaksimalkan fungsi *controller* maka perlu dilakukan *tuning* lebih lanjut terhadap parameter PID pada *controller*. [2]

Kemudian yang akan di lakukan tuning adalah pada masing-masing kontroler yaitu Tipe P (*Proportional*), PI (*Proportional Integral*) dan PID (*Proportional Integral Differential*), seperti terlihat pada gambar 3.11 m enunjukkan adanya proses tuning untuk memaksimalkan fungsi kendali dari PID tersebut, selanjutnya dapat dilihat pada bab 4 mengenai analisa proses tuning tersebut.



Gambar 3.11 Blok diagram dari Tuning pada Sistem Pengendalian *Three Phase Separator*

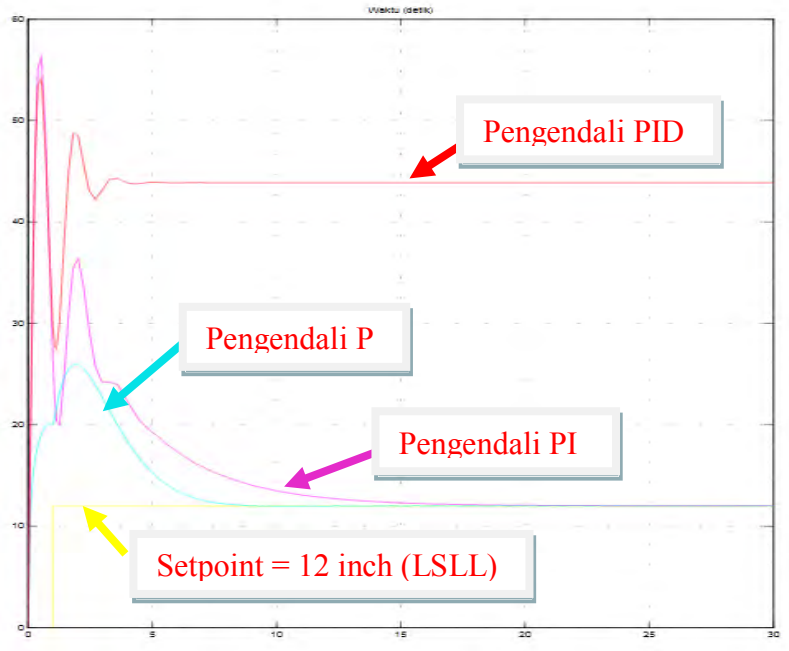
BAB IV
ANALISA DATA DAN PEMBAHASAN

4.1 Analisa Sistem Pengendalian ZN

Pembahasan pada bab ini adalah mengenai tahapan pemodelan dan sistem kontrol pada pengendalian level yang menggunakan pengendali PID. Pada bab ini akan dilakukan analisa dengan menggunakan dimana terdapat sistem pengendali PID dengan metode yang akan dibandingkan satu dan lainya.

Nilai PID tersebut dapat diperoleh menggunakan aturan dasar Ziegler-Nichols yaitu metode kurva reaksi dengan perhitungan MATLAB R2010B.

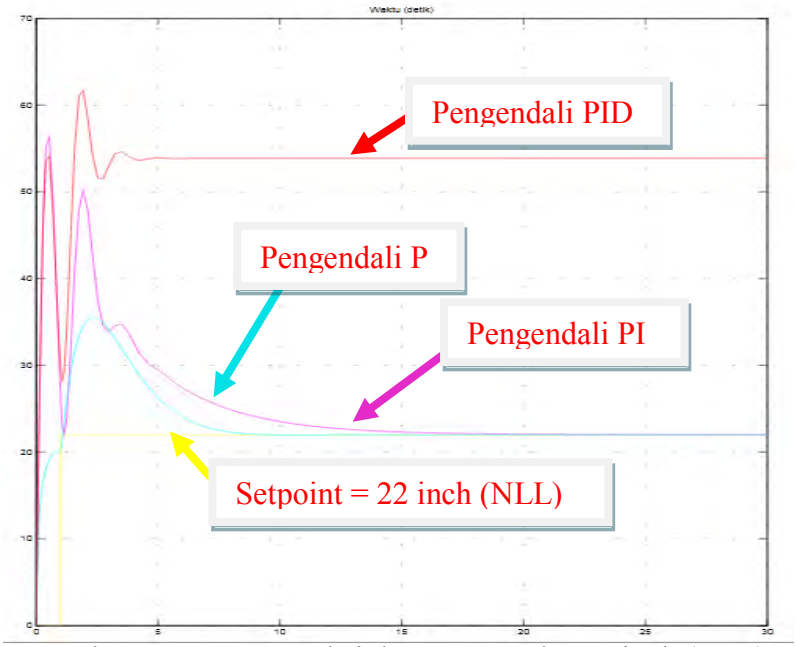
Pada tahap awal ini adalah mencari nilai K_p, K_i, dan K_d dengan simulink pada bab 3, dengan memasukkan nilai setpoint 12 inch (LSLL), 22 inch (NLL) dan 36 inch (LSHH) dari separator serta memasukkan nilai uji step = 1, seperti dibawah ini,



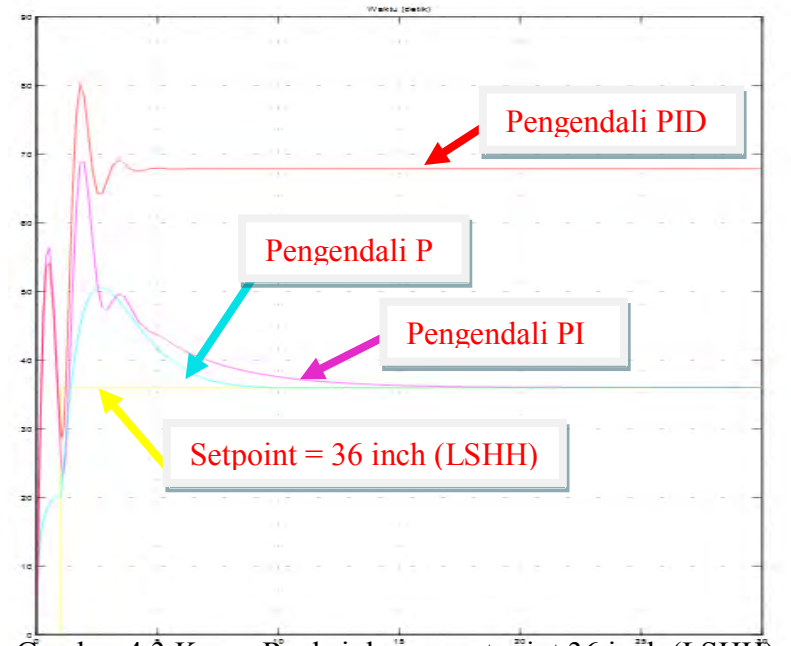
Gambar 4.1 Kurva Reaksi dengan setpoint 12 inch (LSLL)

Dari gambar 4.1, 4.2, da n 4.3 a dalah kontroler P, PI dan PID terjadi kenaikan fluktuatif pada detik ke-0 sampai dengan 4 dari level 0 inch, kemudian P

dan PI steady pada level sesuai dengan setpoint pada detik ke-18, sedangkan PID steady pada detik ke- 4.5 serta menjauhi setpoint.



Gambar 4.2 Kurva Reaksi dengan setpoint 22 inch (NLL)



Gambar 4.3 Kurva Reaksi dengan setpoint 36 inch (LSHH)

Dari ketiga gambar diatas (gambar 4.1, 4.2 da n 4.3), ba hwa pemilihan kendali yang mendekati dengan plant adalah pengendali P dan PI sedangkan kalau dilihat

dari setpointnya tampak seperti diatas memperlihatkan dengan perbedaan setpoint ini tidak akan mempengaruhi nilai dari parameter kendali tersebut.

Maka dari hasil pengujian tersebut didapat:

- Nilai K (Gain) : 56.2443
- Nilai T (Time Constant) : 0.2825
- Nilai L (Time Delay) : 0.0253

Dari nilai diatas maka akan di dapat nilai seperti dibawah ini

Tipe kontroler	**K_P**	**T_I**	**T_D**
P	$\frac{T}{KL} = 0.1985$	-	-
PI	$0.9\frac{T}{KL} = 0.1787$	3L=0.0759	-
PID	$1{,}2\frac{T}{KL} = 0.5786$	2L=0.051	0.5L=0.0126

Table 4.1 Nilai parameter pengendali

Dari Tabel 4.1,

- PI

  Nilai K_i : K_p/T_i

  : 2.3544

- PID

  Nilai K_i : K_p/T_i

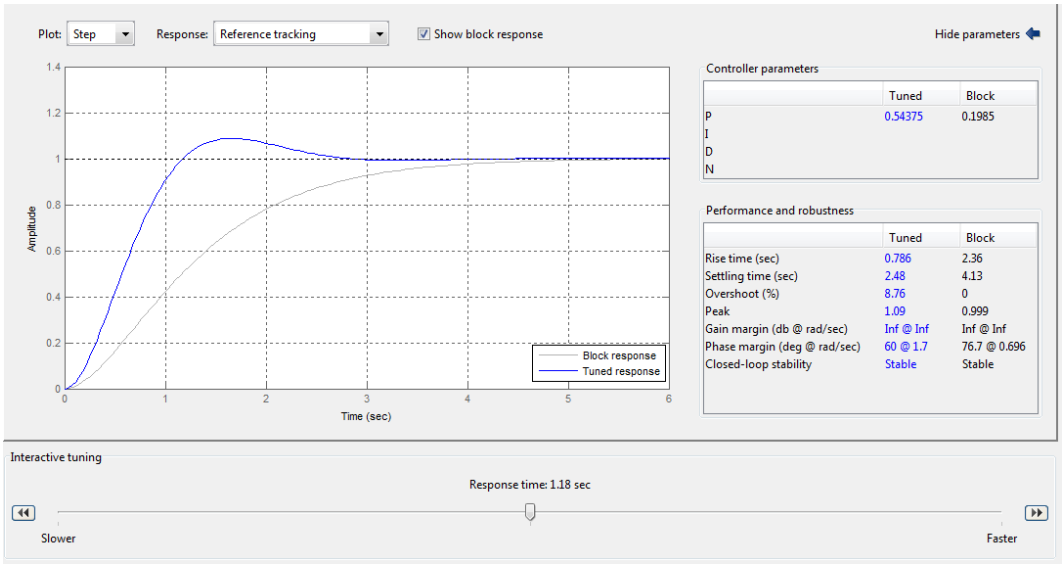
  : 11.3451

  Nilai K_d : $K_p x T_d$

  : 0.0073

Setelah nilai parameter kendali diatas didapat, langkah selanjutnya adalah melakukan tuning dengan memasukkan nilai Kp, Ki dan Kd.

- **Pengendali P**



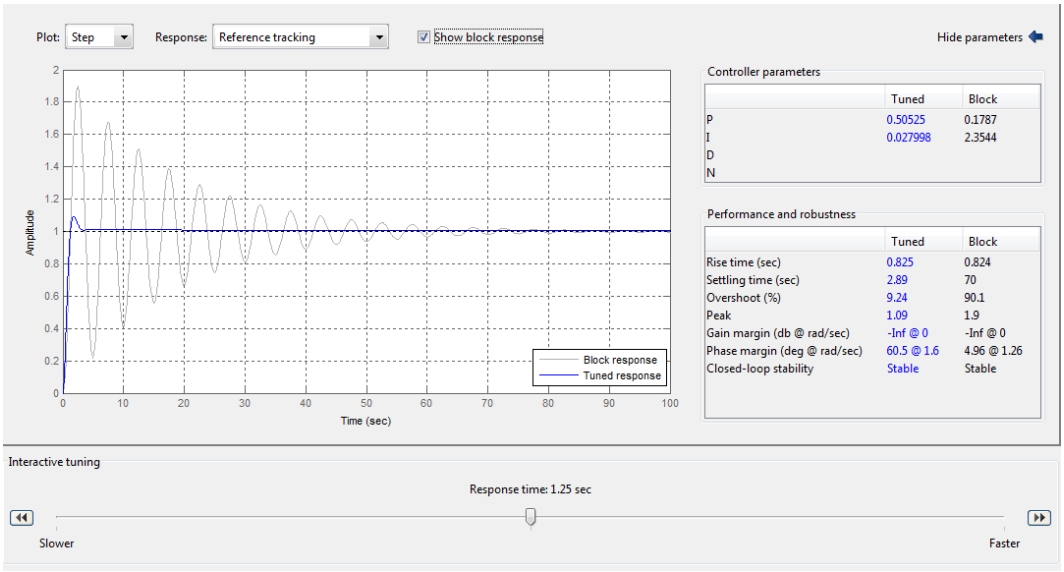
Gambar 4.4 Tuning pengendali P

Dari gambar 4.4 di dapat,

K_p	: 0.54375
Rise Time (Detik)	: 0.786
Settling Time (Detik)	: 2.48
Overshoot (%)	: 8.76
Peak	: 1.09
Closed Loop Stability	: Stable
Response Time (Detik)	: 1.18

Berdasar pada gambar 4.4 setelah me- *running* menggunakan perangkat lunak Matlab menunjukkan hasil tuning dari P kendali adalah garis yang bewarna biru, bahwa analisa dari tuning tersebut adalah stabil dalam performance nya.

- **Pengendali PI**



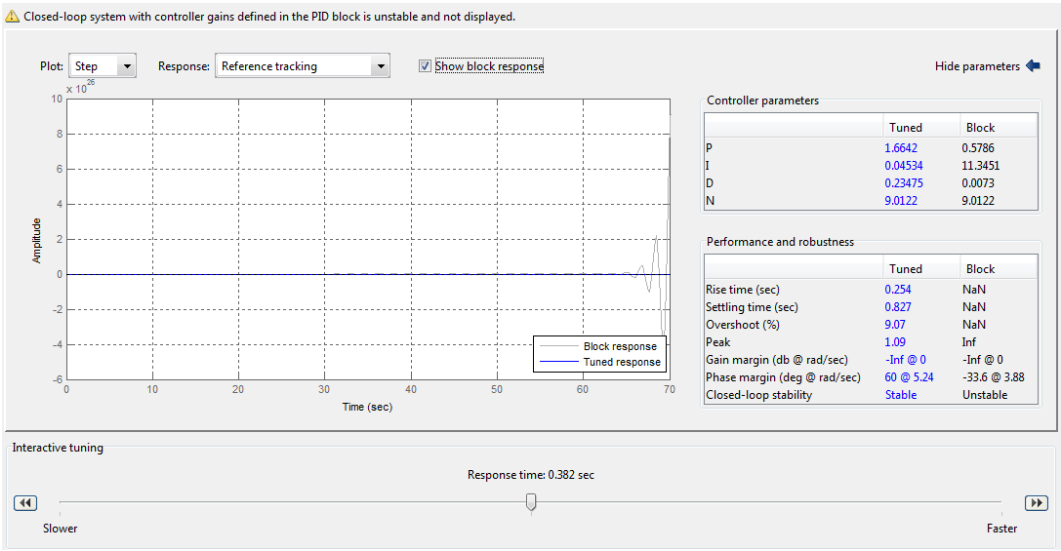
Gambar 4.5 Tuning pengendali PI

Dari gambar 4.5 di dapat,

K_p	: 0.50525
K_i	: 0.002799
Rise Time (Detik)	: 0.825
Settling Time (Detik)	: 2.89
Overshoot (%)	: 9.24
Peak	: 1.09
Closed Loop Stability	: Stable
Response Time (Detik)	: 1.25

Berdasar pada gambar 4.5 setelah me- *running* menggunakan perangkat lunak Matlab menunjukkan hasil tuning dari PI kendali setelah memasukkan parameter kendalinya adalah garis yang bewarna biru, bahwa analisa dari tuning tersebut adalah stabil dalam performance nya meskipun pada blok responsinya adalah osilasi.

- **Pengendali PID**



Gambar 4.6 Tuning pengendali PID

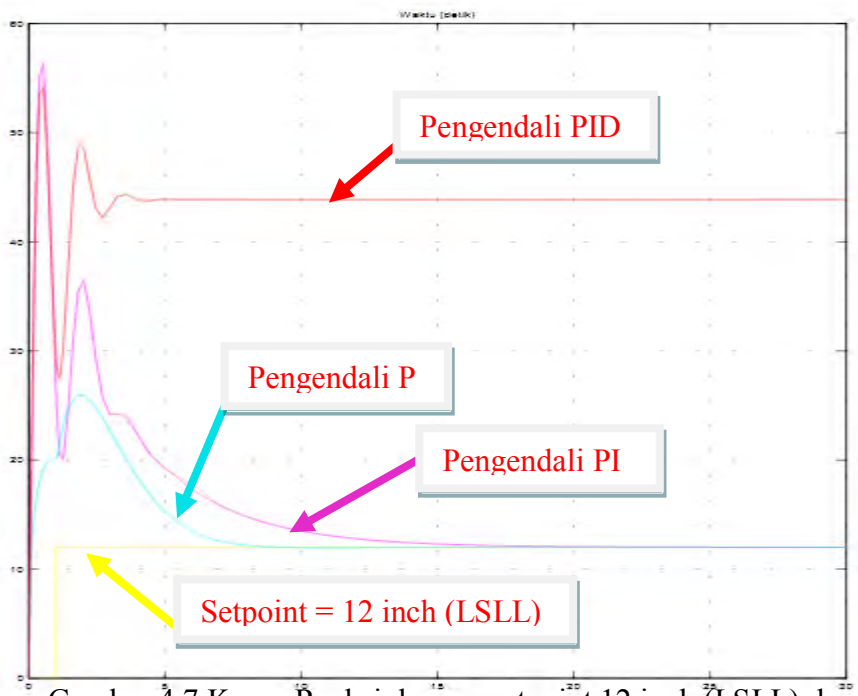
Dari gambar 4.6 di dapat,

K_p	: 1.6642
K_i	: 0.0453
K_d	: 0.2347
Rise Time (Detik)	: 0.254
Settling Time (Detik)	: 2.57
Overshoot (%)	: 9.07
Peak	: 1.09
Closed Loop Stability	: Unstable
Response Time (Detik)	: 0.382

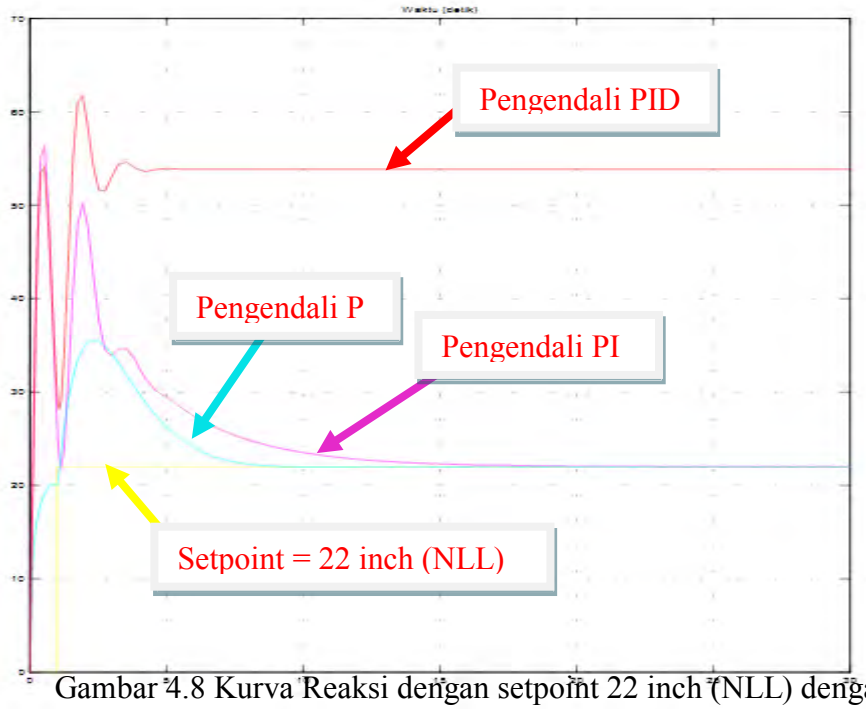
Berdasar pada gambar 4.6 setelah me- *running* menggunakan perangkat lunak Matlab menunjukkan hasil tuning dari pengendali PID adalah garis yang bewarna biru, bahwa analisa dari tuning tersebut adalah tidak stabil dalam performance nya, dikarenakan nilai gain nya terlalu besar sehingga tidak dapat digambarkan.

4.2 Simulasi Dengan *Disturbance*

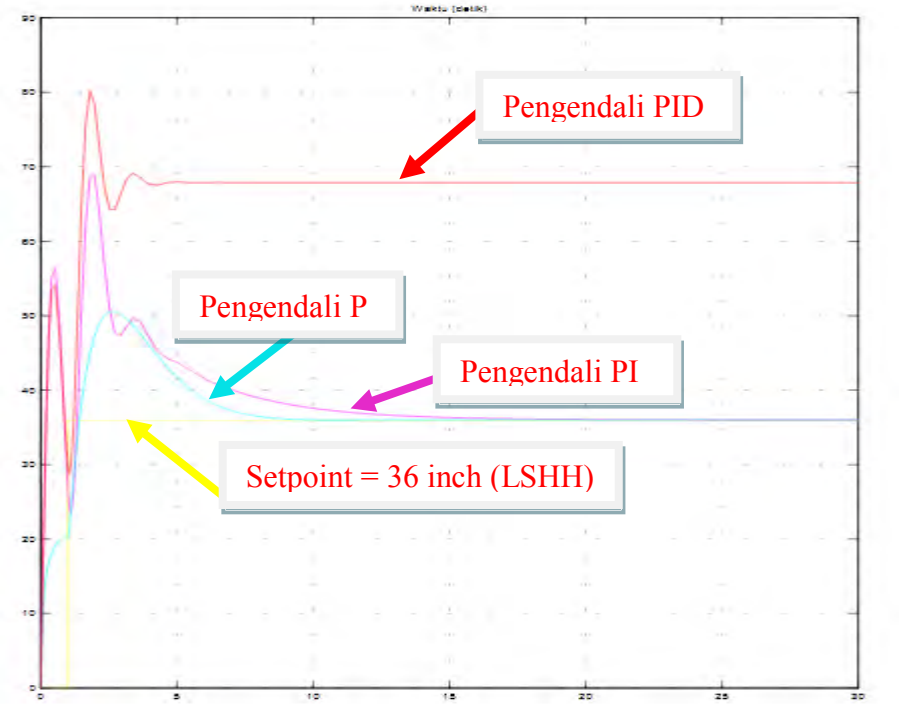
Dalam sistem pengendalian three phase separator ini akan diberi *disturbance* atau gangguan sebesar 5% untuk mengetahui kemampuan fungsinya.



Gambar 4.7 Kurva Reaksi dengan setpoint 12 inch (LSLL) dengan disturbance/gangguan 5%



Gambar 4.8 Kurva Reaksi dengan setpoint 22 inch (NLL) dengan disturbance/gangguan 5%



Gambar 4.9 Kurva Reaksi dengan setpoint 36 inch (LSHH) dengan disturbance/gangguan 5%

Dalam sistem ini terlihat bahwa adanya disturbance atau gangguan sebesar 5% tidak mengganggu kinerja dari *three phase separator* ini seperti yang ditunjukkan gambar 4.7, 4.8 d an 4.9, bahwa sama seperti sistem yang tanpa adanya gangguan, ada saatnya fluktuatif naik dan turun, kemudian saat stabil pada detik ke-18 untuk pengendali P dan PI, sedangkan untuk pengendali PID stabil pada detik ke-4.5 tetapi menjauh dari setpoint.

Langkah selanjutnya adalah melakukan proses tuning dengan memasukkan parameter pengendali, akan mendapatkan hasil seperti dibawah ini:

- **Pengendali P**

  Berdasar pada gambar 4.10 setelah me- *running* menggunakan perangkat lunak Matlab menunjukkan hasil tuning dari P kendali adalah garis yang bewarna biru, bahwa analisa dari tuning tersebut adalah stabil dalam performance nya. Maka akan di dapat,

  K_p : 0.54409

  Rise Time (Detik) : 0.787

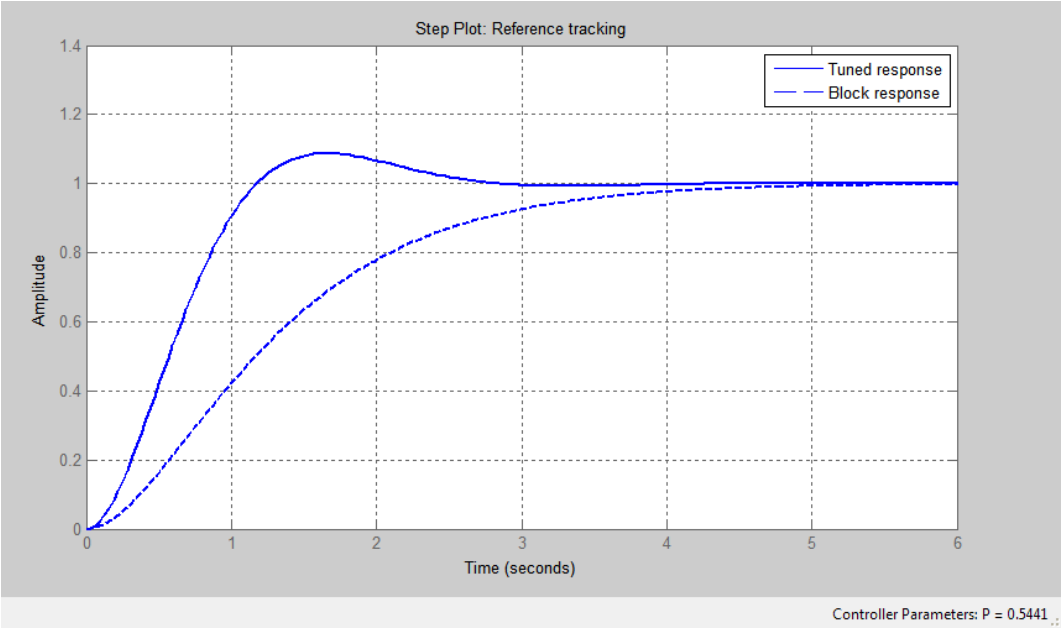
Settling Time (Detik) : 2.48

Overshoot (%) : 8.77

Peak : 1.09

Closed Loop Stability : Stable

Response Time (Detik) : 1.18



Controller Parameters

	Tuned	Block
P	0.54409	0.1985
I		
D		
N		

Performance and Robustness

	Tuned	Block
Rise time	0.785 seconds	2.36 seconds
Settling time	2.48 seconds	4.13 seconds
Overshoot	8.77 %	0 %
Peak	1.09	0.999
Gain margin	Inf dB @ Inf rad/s	Inf dB @ Inf rad/s
Phase margin	60 deg @ 1.7 rad/s	76.7 deg @ 0.696 rad/s
Closed-loop stability	Stable	Stable

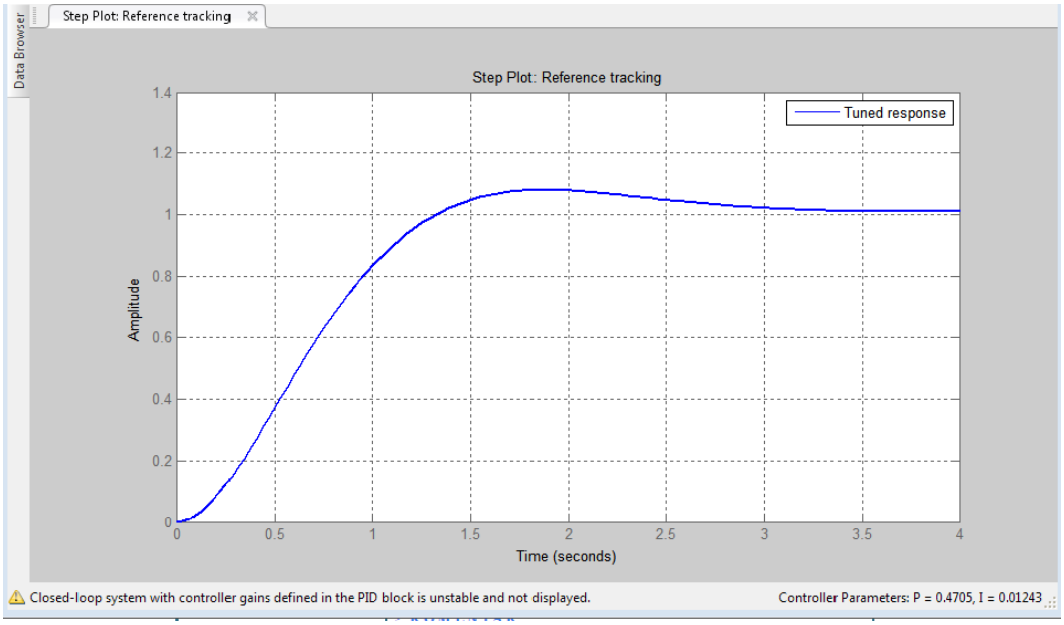
Gambar 4.10 Tuning pengendali P untuk disturbance/gangguan

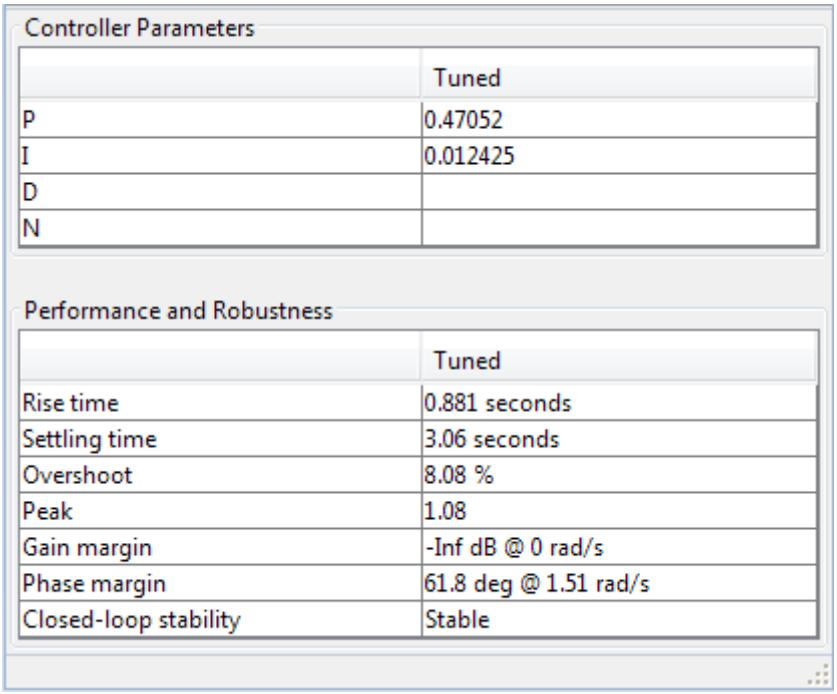
- **Pengendali PI**

  Berdasar pada gambar 4.11 setelah me- *running* menggunakan perangkat lunak Matlab menunjukkan hasil tuning dari PI kendali setelah memasukkan parameter kendalinya adalah garis yang bewarna biru, bahwa analisa dari tuning tersebut adalah stabil dalam performance nya tetapi pada blok responsinya adalah tidak stabil dan tidak bisa di gambarkan.

  Maka akan di dapat,

K_p	: 0.47052
K_i	: 0.012425
Rise Time (Detik)	: 0.881
Settling Time (Detik)	: 3.06
Overshoot (%)	: 8.08
Peak	: 1.08
Closed Loop Stability	: Stable
Response Time (Detik)	: 1.326





Controller Parameters

	Tuned
P	0.47052
I	0.012425
D	
N	

Performance and Robustness

	Tuned
Rise time	0.881 seconds
Settling time	3.06 seconds
Overshoot	8.08 %
Peak	1.08
Gain margin	-Inf dB @ 0 rad/s
Phase margin	61.8 deg @ 1.51 rad/s
Closed-loop stability	Stable

Gambar 4.11 Tuning pengendali PI untuk disturbance/gangguan

- **Pengendali PID**

  Berdasar pada gambar 4.12 setelah me- *running* menggunakan perangkat lunak Matlab menunjukkan hasil tuning dari pengendali PID adalah garis yang bewarna biru, bahwa analisa dari tuning tersebut adalah tidak stabil dalam performance nya, dikarenakan nilai gain nya terlalu besar sehingga tidak dapat digambarkan.

  Maka akan di dapat,

  K_p : 1.6642

  K_i : 0.075457

  K_d : 0.39067

  Rise Time (Detik) : 0.254

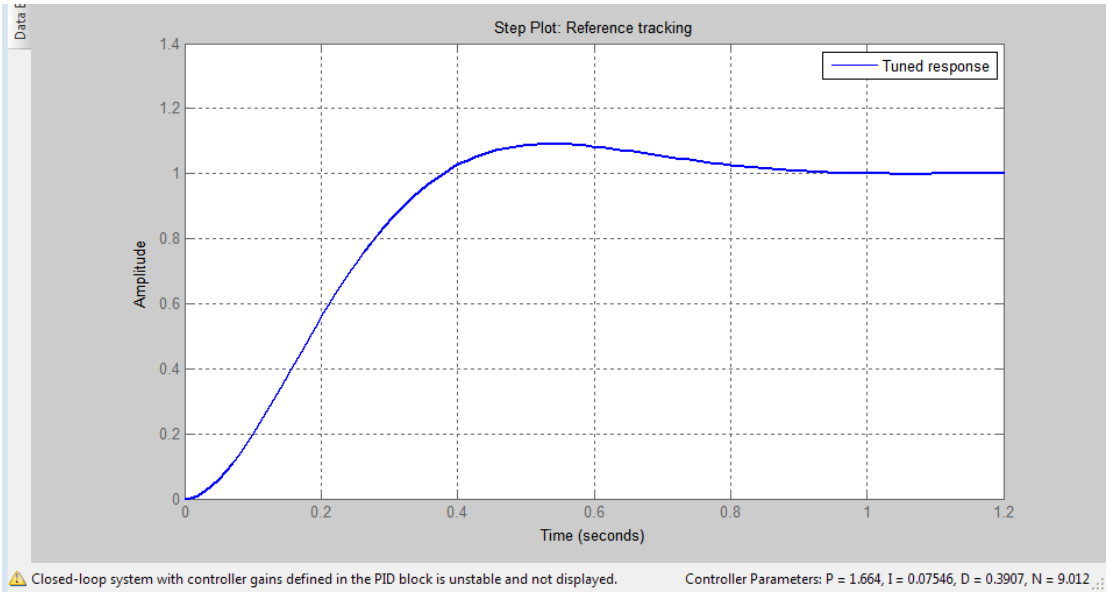
  Settling Time (Detik) : 0.827

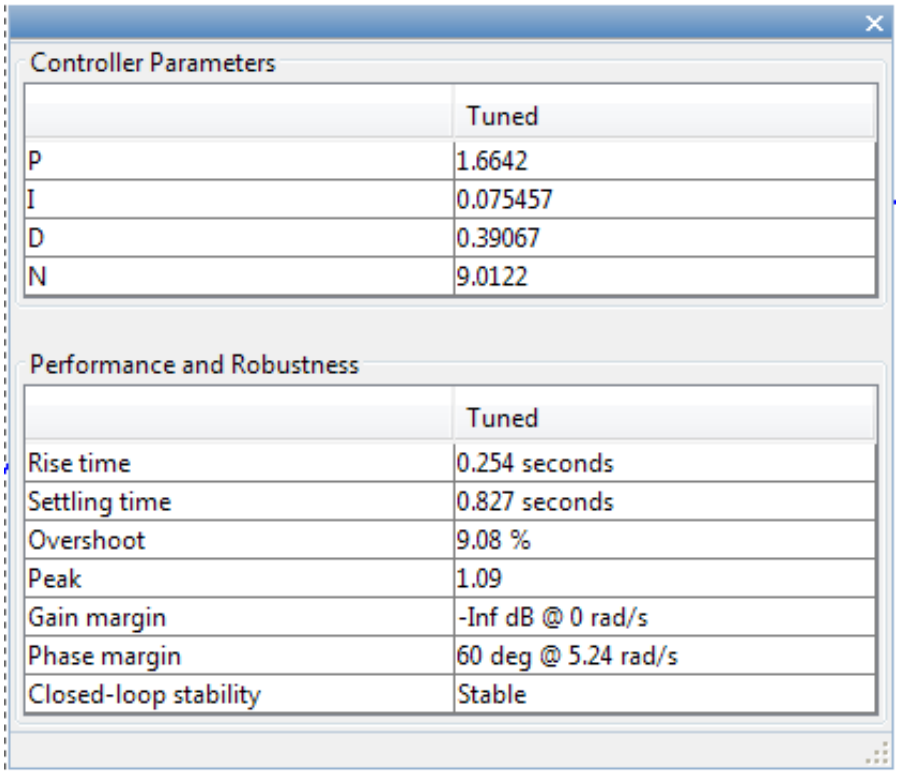
  Overshoot (%) : 9.08

  Peak : 1.09

  Closed Loop Stability : Stable

Response Time (Detik) : 0.3818





Controller Parameters

	Tuned
P	1.6642
I	0.075457
D	0.39067
N	9.0122

Performance and Robustness

	Tuned
Rise time	0.254 seconds
Settling time	0.827 seconds
Overshoot	9.08 %
Peak	1.09
Gain margin	-Inf dB @ 0 rad/s
Phase margin	60 deg @ 5.24 rad/s
Closed-loop stability	Stable

Gambar 4.12 Tuning pengendali PID untuk disturbance/gangguan

Berdasarkan hasil pengujian diatas maka:

NO	DESKRIPSI	PENGENDALI P	PENGENDALI PI	PENGENDALI PID
1	Rise Time (Detik)	0.786	0.825	0.254
2	Settling Time (Detik)	2.48	2.89	2.57
3	Overshoot (%)	8.76	9.24	9.07

Table 4.2 Perbandingan tipe pengendali

NO	DESKRIPSI	PENGENDALI P	PENGENDALI PI	PENGENDALI PID
1	Rise Time (Detik)	0.787	0.881	0.254
2	Settling Time (Detik)	2.48	8.08	0.827
3	Overshoot (%)	8.77	9.24	9.08

Table 4.3 Perbandingan tipe pengendali dengan disturbance/gangguan

Dari Tabel 4.2. dan 4.3 menyatakan bahwa tipe pengendali yang menghasilkan kestabilan performansi dari sistem tersebut adalah tipe pengendali P sedangkan tipe pengendali yang lainnya tidak stabil.

(Halaman Ini Sengaja Dikosongkan)

BAB V
KESIMPULAN DAN SARAN

5.1 Kesimpulan

Dalam penelitian, pengujian serta analisa, dapat diambil kesimpulan sebagai berikut:

1. Telah dapat dilakukan analisa kinerja sistem pengendalian level minyak pada *three phase separator* menggunakan pendekatan *separator geometry*.
2. Pengendalian level minyak menggunakan sistem pengendalian *three phase separator* ini memberikan hasil terbaik menggunakan pengendali (P, PI, dan PID) dengan nilai nilai Kp : 0.1985, K_i : 2.3544, K_d : 0.0073, namun setelah dilakukan tuning mendapatkan hasil tidak stabil untuk pengendali PI dan PID).
3. Berdasarkan hasil analisa menggunakan pendekatan *separator geometry* menyatakan bahwa pengendalian yang sesuai untuk *three phase separator* ini adalah Pengendali P dengan nilai overshoot 8.77% dan settling time 2.48 detik.

5.2 Saran

Saran yang dapat diberikan untuk kedepannya adalah untuk penelitian selanjutnya bisa menggunakan metode-metode lain contohnya APC, Fuzzy logic, dll.

(Halaman Ini Sengaja Dikosongkan)

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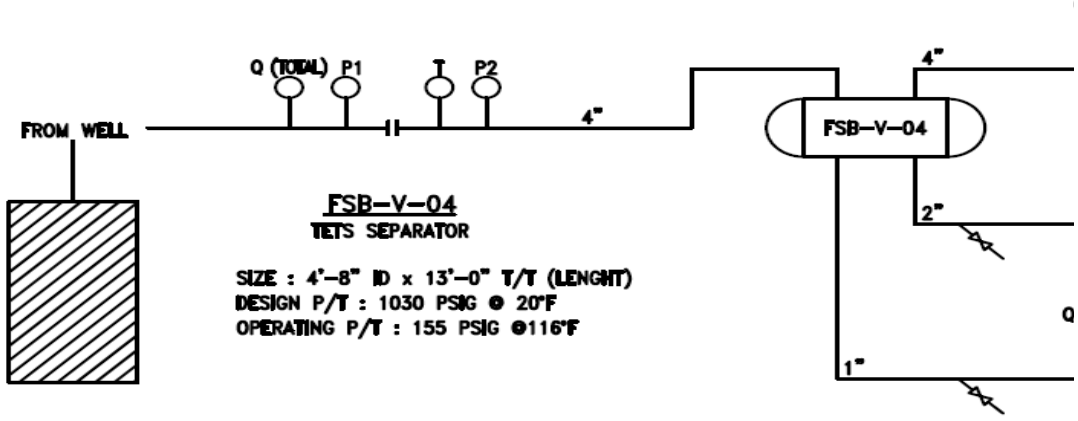
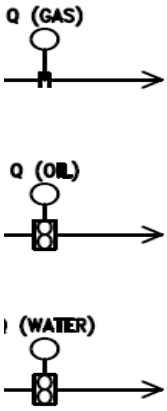
[20] Zomorrodi, M. S. (1982). *Comparison of PID Controller Tuning Methods* , 12.

FOXTROT PLATFORM



FSB–V–04
TETS SEPARATOR

SIZE : 4'–8" ID x 13'–0" T/T (LENGHT)
DESIGN P/T : 1030 PSIG @ 20°F
OPERATING P/T : 155 PSIG @116°F

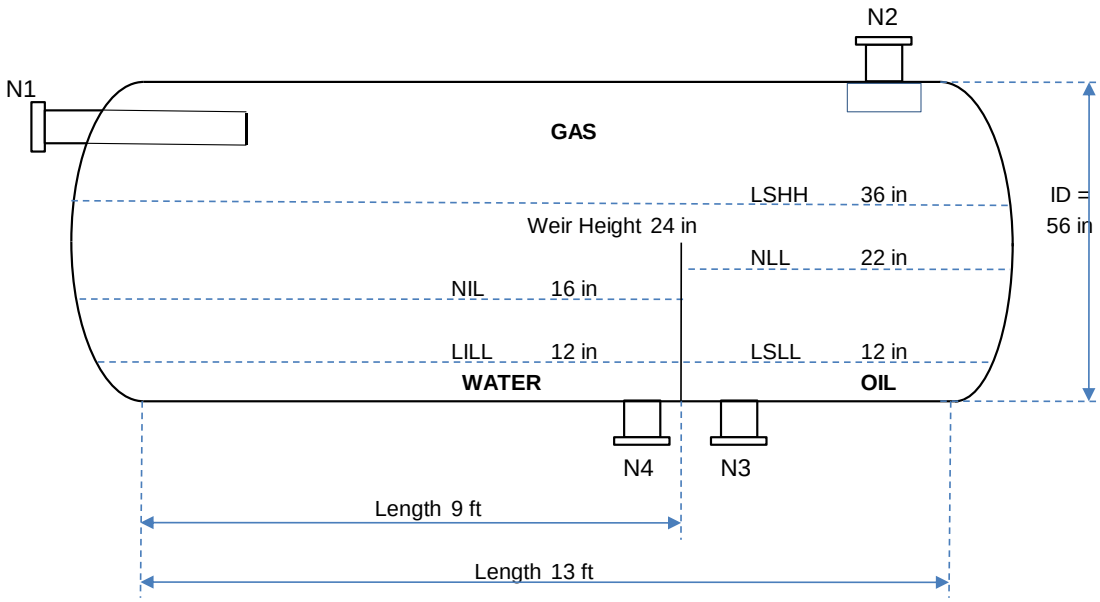

Q (GAS)
Q (OIL)
(WATER)

PERTAMINA PHE ONWJ	PROCESS CALCULATION 3 PHASE HORIZONTAL SEPARATOR WITH WEIR		
Project	FSB Field Development		
Area	FSB Platform	Revision	0
Equipment	Test Separator (FSB-V-04)	Page	3 of 3

NOZZLE SIZING

	Calculated	Selected	Selected	Remark
Inlet Schoepentoeter or equivalent	2,20 in	6 in	73 lb/ft/s^2	***OK***
Gas outlet	2,00 in	6 in	4 lb/ft/s^2	***OK***
Oil outlet	2,00 in	2 in	3 ft/s	***OK***
Water outlet	2,00 in	2 in	1 ft/s	***OK***

SKETCH



Where:
N1 = Inlet Nozzle
N2 = Gas Outlet Nozzle
N3 = Oil Outlet Nozzle
N4 = Water Outlet Nozzle

Rev.	Date	Description	Prepared by	Reviewed by	Approved by
A	9-Jan-13	IFR	AWS	UNS	JND/MN
B	6-Feb-13	IFA	AWS	UNS	JND/MN
0	20-Feb-13	IFD	AWS	UNS	JND/MN
1	28-Mar-13	Re-IFD	AWS	UNS	JND/MN
2	15-Apr-13	AFC	AWS	UNS	JND/MN

PERTAMINA
PHE ONWJ

PERTAMINA HULU ENERGI

FOXTROT WELL PLATFORM

DATA SEPARATOR (FSB-V-04)

FOXTROT WELL PLATFORM - 1L

BULAN : MARET 2012

NO	WAKTU		OUTLET WELL (FSB-01L)				OUTLET SEPARATOR (FSB-V-04)			LEVEL SEPARATOR (FSB-V-04)
	Tanggal	Pukul	Q (Total) BBL/Day	P1 (PSI)	P2 (PSI)	T (deg F)	Q (Gas) MMSCFD	Q (Oil) BOPD	Q (water) BWPD	Oil (inchi)
			FQI-FSB-01	PI-FSB-01A	PI-FSB-01B	TI-FSB-01	FQI-FSB-V-04A	FQI-FSB-V-04B	FQI-FSB-V-04C	LG-FSB-V-01
1	01-03-2012	07.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38	14
		14.00	1120,89	278,00	275,00	109,89	1,39	429,48	27,07	15
		20.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38	14
2	02-03-2012	07.00	1120,89	278,00	275,00	109,89	1,39	429,48	27,07	13
		14.00	1120,39	278,00	274,00	109,96	1,40	429,20	26,07	14
		20.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38	12
3	03-03-2012	07.00	1120,39	278,00	274,00	110,00	1,40	429,15	26,07	13
		14.00	1120,89	279,00	274,00	112,04	1,40	426,85	27,01	13
		20.00	1120,89	278,00	275,00	112,00	1,40	427,03	27,01	13
4	04-03-2012	07.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38	15
		14.00	1120,40	280,00	276,00	110,00	1,39	430,88	27,08	14
		20.00	1121,40	279,00	275,00	111,00	1,39	430,56	27,55	15
5	05-03-2012	07.00	1120,40	279,00	275,00	111,99	1,40	428,25	27,02	14
		14.00	1120,40	280,00	275,00	111,99	1,40	428,29	27,02	14
		20.00	1120,40	280,00	276,00	109,00	1,39	432,07	27,11	14
6	06-03-2012	07.00	1120,89	279,00	275,00	109,94	1,39	429,52	27,07	15
		14.00	1120,89	279,00	275,00	110,00	1,39	430,57	27,07	16
		20.00	1120,89	278,00	275,00	110,00	1,39	430,53	27,07	16
7	07-03-2012	07.00	1121,40	279,00	274,00	109,00	1,39	432,68	27,60	16
		14.00	1120,97	278,00	274,00	110,64	1,40	428,85	27,37	16
		20.00	1120,97	278,00	274,00	110,64	1,40	428,85	27,37	15
8	08-03-2012	07.00	1119,89	279,00	274,00	110,00	1,39	429,16	27,07	16
		14.00	1119,89	279,00	275,00	111,00	1,39	429,42	26,05	14
		20.00	1120,39	278,00	274,00	111,00	1,40	427,98	26,04	14
9	09-03-2012	07.00	1120,89	278,00	275,00	110,00	1,39	430,53	27,07	14
		14.00	1121,40	279,00	275,00	112,00	1,39	429,45	27,52	16
		20.00	1122,89	278,00	273,00	111,00	1,40	430,26	27,04	16
10	10-03-2012	07.00	1122,12	279,00	275,00	112,04	1,40	429,41	27,25	13
		14.00	1120,40	279,00	275,00	109,00	1,39	431,80	27,10	14
		20.00	1121,40	279,00	274,00	111,00	1,39	430,33	27,55	14
11	11-03-2012	07.00	1120,40	279,00	275,00	110,00	1,39	430,56	27,07	14
		14.00	1120,40	279,00	275,00	111,00	1,39	429,39	27,05	12
		20.00	1120,40	280,00	276,00	111,99	1,40	428,51	27,02	11
12	12-03-2012	07.00	1120,40	278,00	274,00	110,00	1,39	429,11	29,08	14
		14.00	1120,40	279,00	274,00	110,00	1,39	429,15	29,08	14
		20.00	1120,40	279,00	274,00	111,00	1,39	427,92	29,05	15
13	13-03-2012	07.00	1121,40	279,00	274,00	109,00	1,39	432,68	27,60	13
		14.00	1120,40	279,00	276,00	110,00	1,39	429,54	29,08	16
		20.00	1121,89	279,00	276,00	109,93	1,39	434,48	25,08	16
14	14-03-2012	07.00	1121,89	279,00	276,00	109,93	1,39	434,48	25,08	16
		14.00	1121,89	279,00	275,00	109,93	1,39	434,25	25,08	15
		20.00	1120,40	279,00	275,00	111,00	1,39	428,15	29,05	15
15	15-03-2012	07.00	1120,40	279,00	275,00	111,00	1,39	428,15	29,05	14
		14.00	1120,40	279,00	276,00	111,00	1,39	428,37	29,05	14
		20.00	1121,89	279,00	275,00	109,93	1,39	434,25	25,08	13
16	16-03-2012	07.00	1121,89	279,00	275,00	107,85	1,39	436,73	25,13	15
		14.00	1121,89	279,00	275,00	107,85	1,39	436,73	25,13	14
		20.00	1121,89	280,00	276,00	110,00	1,39	434,49	25,08	13
17	17-03-2012	07.00	1122,39	278,00	273,00	109,99	1,39	433,65	25,07	13
		14.00	1122,39	278,00	273,00	109,99	1,39	433,65	25,07	12
		20.00	1121,89	279,00	275,00	111,99	1,40	431,85	25,02	12
18	18-03-2012	07.00	1122,39	278,00	273,00	109,99	1,39	433,65	25,07	12
		14.00	1122,39	278,00	273,00	111,00	1,40	432,47	25,04	15

		20.00	1122,39	278,00	273,00	111,00	1,40	432,47	25,04	14
19	19-03-2012	07.00	1122,41	278,00	274,00	109,00	1,38	434,83	29,10	13
		14.00	1122,41	278,00	274,00	109,00	1,38	434,83	29,10	13
		20.00	1121,89	279,00	275,00	111,99	1,40	431,85	25,02	13
20	20-03-2012	07.00	1121,89	280,00	275,00	111,99	1,40	431,89	25,02	15
		14.00	1122,89	278,00	273,00	111,00	1,40	430,26	27,04	15
		20.00	1122,89	278,00	274,00	111,00	1,40	430,48	27,05	16
21	21-03-2012	07.00	1122,89	278,00	274,00	111,00	1,40	430,48	27,05	15
		14.00	1121,89	280,00	276,00	111,99	1,40	432,12	25,02	15
		20.00	1121,89	280,00	276,00	111,99	1,40	432,12	25,02	14
22	22-03-2012	07.00	1121,89	280,00	276,00	109,00	1,39	435,68	25,10	14
		14.00	1121,89	280,00	276,00	109,00	1,39	435,68	25,10	13
		20.00	1120,40	279,00	276,00	109,00	1,39	430,72	29,10	15
23	23-03-2012	07.00	1121,89	279,00	275,00	111,99	1,40	431,85	25,02	14
		14.00	1121,89	280,00	276,00	110,00	1,39	434,49	25,08	14
		20.00	1121,89	280,00	276,00	110,00	1,39	434,49	25,08	15
24	24-03-2012	07.00	1122,89	278,00	273,00	111,00	1,40	430,26	27,04	13
		14.00	1121,89	280,00	276,00	110,00	1,39	434,49	25,08	17
		20.00	1120,40	279,00	276,00	111,00	1,39	428,37	29,05	14
25	25-03-2012	07.00	1120,40	279,00	276,00	109,00	1,39	430,72	29,10	14
		14.00	1119,89	279,00	274,00	112,04	1,40	426,80	27,01	15
		20.00	1119,89	279,00	275,00	110,00	1,39	429,39	27,07	13
26	26-03-2012	07.00	1119,89	279,00	274,00	110,00	1,39	429,16	27,07	12
		14.00	1119,92	279,00	275,00	110,84	1,39	430,80	25,08	15
		20.00	1119,64	279,00	275,00	111,96	1,39	429,27	27,25	15
27	27-03-2012	07.00	1119,92	279,00	275,00	110,84	1,39	430,80	25,08	14
		14.00	1119,89	279,00	274,00	110,00	1,39	429,16	27,07	13
		20.00	1120,40	279,00	275,00	109,00	1,39	431,80	27,10	14
28	28-03-2012	07.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38	12
		14.00	1119,92	279,00	275,00	110,84	1,39	430,80	25,08	16
		20.00	1119,92	279,00	275,00	110,84	1,39	430,80	25,08	15
29	29-03-2012	07.00	1120,40	279,00	276,00	109,00	1,39	430,72	29,10	14
		14.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38	14
		20.00	1120,40	279,00	276,00	109,00	1,39	430,72	29,10	15
30	30-03-2012	07.00	1119,92	279,00	275,00	110,84	1,39	430,80	25,08	13
		14.00	1120,40	279,00	276,00	109,00	1,39	430,72	29,10	13
		20.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38	14

PERTAMINA HULU ENERGI

FOXTROT WELL PLATFORM

DATA SEPARATOR (FSB-V-04)

FOXTROT WELL PLATFORM - 1L

BULAN : JUNI 2012

NO	WAKTU		OUTLET WELL (FSB-01L)				OUTLET SEPARATOR (FSB-V-04)		
	Tanggal	Pukul	Q (Total) BBL/Day	P1 (PSI)	P2 (PSI)	T (deg F)	Q (Gas) MMSCFD	Q (Oil) BOPD	Q (water) BWPD
			FQI-FSB-01	PI-FSB-01A	PI-FSB-01B	TI-FSB-01	FQI-FSB-V-04A	FQI-FSB-V-04B	FQI-FSB-V-04C
1	01-06-2012	07.00	1118,90	278,00	273,00	109,00	1,39	431,14	26,60
		14.00	1119,39	277,00	273,00	109,94	1,40	427,70	26,07
		20.00	1118,40	279,00	275,00	112,00	1,40	427,05	26,02
2	02-06-2012	07.00	1118,90	279,00	274,00	109,00	1,39	431,41	26,60
		14.00	1119,39	279,00	274,00	110,03	1,40	428,02	26,07
		20.00	1118,90	279,00	274,00	109,00	1,39	431,41	26,60
3	03-06-2012	07.00	1118,89	278,00	274,00	109,93	1,40	428,02	26,07
		14.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
		20.00	1118,90	279,00	275,00	112,00	1,39	428,19	26,52
4	04-06-2012	07.00	1118,90	278,00	274,00	109,00	1,39	431,37	26,60
		14.00	1118,90	278,00	275,00	109,00	1,39	431,60	26,60
		20.00	1117,91	278,00	274,00	111,00	1,39	427,86	27,05
5	05-06-2012	07.00	1117,91	278,00	274,00	109,00	1,39	430,15	27,10
		14.00	1117,91	279,00	275,00	111,00	1,39	428,13	27,05
		20.00	1117,91	278,00	275,00	111,00	1,39	428,09	27,05
6	06-06-2012	07.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
		14.00	1118,39	278,00	274,00	109,99	1,39	427,92	26,07
		20.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
7	07-06-2012	07.00	1116,00	278,00	274,00	112,00	1,39	427,40	27,35
		14.00	1118,39	278,00	274,00	109,99	1,39	427,92	26,07
		20.00	1118,39	278,00	274,00	109,99	1,39	427,92	26,07
8	08-06-2012	07.00	1119,39	279,00	274,00	110,03	1,40	428,02	26,07
		14.00	1118,90	279,00	274,00	109,00	1,39	431,41	26,60
		20.00	1118,90	279,00	274,00	109,00	1,39	431,41	26,60
9	09-06-2012	07.00	1119,39	279,00	274,00	110,03	1,40	428,02	26,07
		14.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
		20.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
10	10-06-2012	07.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
		14.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38
		20.00	1119,39	277,00	273,00	109,94	1,40	427,70	26,07
11	11-06-2012	07.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38
		14.00	1120,97	278,00	274,00	110,64	1,40	428,85	27,37
		20.00	1120,97	279,00	275,00	111,00	1,39	429,12	27,38
12	12-06-2012	07.00	1118,90	278,00	273,00	111,00	1,39	428,80	26,54
		14.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
		20.00	1118,40	279,00	275,00	111,04	1,39	428,15	26,04
13	13-06-2012	07.00	1118,40	279,00	275,00	111,04	1,39	428,15	26,04
		14.00	1118,40	279,00	275,00	111,04	1,39	428,15	26,04
		20.00	1118,40	279,00	275,00	111,04	1,39	428,15	26,04
14	14-06-2012	07.00	1118,40	279,00	275,00	111,04	1,39	428,15	26,04
		14.00	1118,40	279,00	275,00	111,04	1,39	428,15	26,04
		20.00	1118,90	278,00	273,00	111,00	1,39	428,80	26,54
		07.00	1118,90	278,00	273,00	111,00	1,39	428,80	26,54

15	15-06-2012	14.00	1118,90	279,00	275,00	111,00	1,39	429,29	26,55
		20.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
16	16-06-2012	07.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
		14.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
		20.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
17	17-06-2012	07.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
		14.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
		20.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
18	18-06-2012	07.00	1117,91	278,00	274,00	111,00	1,39	427,86	27,05
		14.00	1117,91	278,00	274,00	109,00	1,39	430,15	27,10
		20.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
19	19-06-2012	07.00	1117,91	278,00	274,00	111,00	1,39	427,86	27,05
		14.00	1118,89	279,00	275,00	109,97	1,40	428,29	26,07
		20.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
20	20-06-2012	07.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
		14.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
		20.00	1118,89	278,00	274,00	109,93	1,40	428,02	26,07
21	21-06-2012	07.00	1118,89	279,00	275,00	109,97	1,40	428,29	26,07
		14.00	1118,90	279,00	275,00	109,00	1,39	431,69	26,60
		20.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
22	22-06-2012	07.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
		14.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
		20.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
23	23-06-2012	07.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
		14.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
		20.00	1116,41	277,00	273,00	111,00	1,39	428,61	26,04
24	24-06-2012	07.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
		14.00	1122,89	278,00	273,00	111,00	1,40	430,26	27,04
		20.00	1118,41	277,00	273,00	111,00	1,39	429,84	26,04
25	25-06-2012	07.00	1122,89	278,00	273,00	111,00	1,40	430,26	27,04
		14.00	1122,89	278,00	273,00	111,00	1,40	430,26	27,04
		20.00	1120,89	278,00	275,00	110,00	1,39	430,53	27,07
26	26-06-2012	07.00	1117,91	278,00	274,00	109,00	1,39	430,15	27,10
		14.00	1119,89	279,00	275,00	111,00	1,39	429,42	26,05
		20.00	1120,89	278,00	275,00	110,00	1,39	430,53	27,07
27	27-06-2012	07.00	1119,89	279,00	275,00	111,00	1,39	429,42	26,05
		14.00	1119,92	279,00	275,00	110,84	1,39	430,80	25,08
		20.00	1119,89	279,00	275,00	111,00	1,39	429,42	26,05
28	28-06-2012	07.00	1120,89	278,00	275,00	110,00	1,39	430,53	27,07
		14.00	1118,40	279,00	275,00	111,04	1,39	428,15	26,04
		20.00	1119,89	279,00	275,00	111,00	1,39	429,42	26,05
29	29-06-2012	07.00	1117,91	278,00	274,00	109,00	1,39	430,15	27,10
		14.00	1117,91	278,00	274,00	110,00	1,39	428,97	27,07
		20.00	1120,40	278,00	274,00	110,00	1,39	429,11	29,08
30	30-06-2012	07.00	1120,89	278,00	275,00	110,00	1,39	430,53	27,07
		14.00	1119,89	279,00	275,00	111,00	1,39	429,42	26,05
		20.00	1119,89	279,00	275,00	111,00	1,39	429,42	26,05

PERTAMINA PHE ONWJ

PROCESS CALCULATION

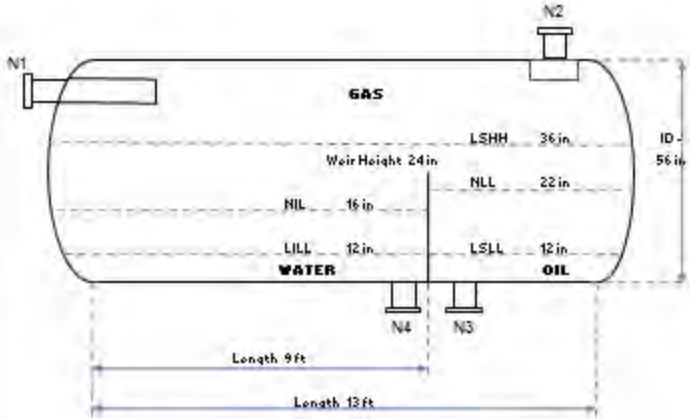
3 PHASE HORIZONTAL SEPARATOR WITH WEIR

Project	FSB Field Development		
Area	FSB Platform	Revision	0
Equipment	Test Separator (FSB-V-04)	Page	3 of 3

NOZZLE SIZING

	Calculated	Selected	Selected	Remark
Inlet Schedule 40 or equivalent	2.20 in	6 in	73 $lb/ft.s^2$	OK
Gas outlet	2.00 in	6 in	4 $lb/ft.s^2$	OK
Oil outlet	2.00 in	2 in	3 ft/s	OK
Water outlet	2.00 in	2 in	1 ft/s	OK

SKETCH



Where:
N1 - Inlet Nozzle
N2 - Gas Outlet Nozzle
N3 - Oil Outlet Nozzle
N4 - Water Outlet Nozzle

PT PERTAMINA (PERSERO)

☑ APPROVED

☐ APPROVED WITH COMMENT

☐ NOT APPROVED

DATE	CHECKED	APPROVED

CLIENT : PT PERTAMINA (PERSERO)

CONTRACTOR : PT. WIJAYA KARYA (PERSERO) TBK

PROJECT NAME : PENGEMBANGAN TERMINAL BBM PULAU SAMBU

LOCATION : PULAU SAMBU, RIAU ISLANDS, INDONESIA

CONTRACT NO. :

PERTAMINA
FOR CONSTRUCTION
Sign : Date : 16-2-15

REV.	DATE	DESC.	PRE'D	CHECKED	APPROVED	CHECKED	APPROVED	APPROVED
			PT.WIJAYA KARYA			PT.AUDEX INDONESIA		PT.PERTAMINA
1	13 Aug '14	Issued For Approved	HA/KA	DA/NK	ADW			
0	28 Mar '14	Issued For Review	NVR/KA	DA/NK	ADW			

REVISION SHEET

No.	Revision	Date	Description
1.	0	28 Mar '14	Review by Audex
2.	1	13 Aug '14	Add information about instrument process connection, tubing, grounding instrument

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 GENERAL

PT. PERTAMINA plans to make refurbishment on Pulau Sambu Fuel Terminal At Pulau Sambu, Riau Islands, Indonesia. The scope of work comprises the following facilities:

- Detail design engineering, procurements, construction, testing and pre-commission of the modification existing storage tank and additional storage tank facilities.
- Detail design engineering, procurements, construction, testing and pre-commission of pumping station facilities and piping for new product.
- Detail design engineering, procurements, construction, testing and pre-commission of blending system.

1.2 SCOPE

This specification defines the minimum requirements for the design standards and engineering practices to be used on the instrumentations systems. Any commissions or details in this specification shall not be relieves the Contractor or Supplier of the obligation to furnish instrumentation that is complete and fully operational.

1.3 DEFINITIONS AND ABBREVIATIONS

DEFINITIONS

The following terms as used in this specification assume the meanings given below:

COMPANY	: This shall mean PT. PERTAMINA (PERSERO)
CONTRACTOR	:The Company of Engineering, Procurement, and Construction, This shall mean PT.WIJAYA KARYA (PERSERO) TBK
VENDOR	: The supplier, manufacture or the owner of material and equipment, chosen by the COMPANY or proposed by the CONTRACTOR and approval by the COMPANY.

ABBREVIATIONS

ATG	Automatic Tank Gauge
CCR	Central Control Room
DCS	Distribution Control System
ESD	Emergency Shutdown system
HMI	Human Machine Interface
MOV	Motor Operating Valve
PCS	Process Control System
PLC	Programmable Logic Controller
UPS	Uninterrupted Power System
CPU	Central Processing Unit

1.4 REFERENCES, CODES, AND STANDARDS

INTERNATIONAL CODES AND STANDARDS

All specified works, instruments and control equipment shall be in accordance with all applicable sections of the latest editions of the following codes and standards (and their current amendments), listed in alphabetical order of issuing authorities and numerical order of designation.

American petroleum Institute (API)

API RP 500	Hazardous Area Clasification
API RP 551	Process Measurement Instrumentation
API RP 550	Installation for Refinery Instrument and Control systems

International Electro-technical Commission (IEC)

IEC 60073	Basic and Safety principles for man-machine interface – Coding principles for Indicator and actuator
IEC 60445	Basic and safety principles for man-machine interface , marking and identification – Identification of Equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system
IEC 60529	Classification of Degree of Protection Provided by Enclosures.
IEC 60770-1	Transmitter for use in Industrial Process Control System Part 1- Method for Performance Evaluation
IEC 61131-1/2	Programmable Controllers General Information, Equipment Requirements and Tests

Instrument, System and Automation Society (ISA)

ISA-RP12.I-1960	Electrical Instrumentation in Hazardous Atmosphere
ISA-S12.4-1970	Instrument Purging for Reduction of Hazardous Area Classification

ANSI/ISA-RP12.6-1997	Installation of Intrinsically Safe Instrument System in Class I Hazardous Locations
S5.1	Instrument symbols and identification.
S5.2	Binary Logic Diagrams for Process Operation.
S5.3	Graphic Symbols for Distributed Control Shared Display Instrumentation.
S5.4	Instrument Loop diagrams.
S5.5	Graphic Symbols for Process Display.
S18.1	Alarm Sequence.
S75.1	Control valve sizing equations.
S75.2	Control valve Procedure Capacity test.
S75.01	Uniform face to face dimensions for flange globe style control valve bodies.

International Standard Organisation (ISO)

ISO 3511	Process measurement and control function an instrumentation - symbolic representation.
ISO 9000	Quality system

National Electrical Manufacturers Association (NEMA)

ICS6-1983 (R1984)	Enclosure for Industrial Controls and Systems

National Fire Protection Association (NFPA)

ANSI/NFPA 70-1987	National Electrical Code Handbook
ANSI/NFPA496-1989	Purged and Pressurized Enclosure for Electrical Equipment

PROJECT DOCUMENT

All specified works, instruments and control equipment shall be in accordance with all applicable sections of the latest editions of the following Project General DOCUMENT (and their current amendments), listed here after.

1.5 CONFLICTING REQUIREMENTS

In the event of conflicts between this specification and the above listed applicable regulations, codes and standards, All apparent conflicts shall be reported to COMPANY for resolution, the following order of precedence shall be followed:

1. Enquiry / Purchase Order
2. Datasheets
3. This Specification
4. Company Specification
5. International Codes and Standards
6. Other related documents

Compliance with the statutory requirements of the Indonesian Authorities is Mandatory. It shall be the CONTRACTOR responsibility to raise to COMPANY any discrepancy between documents. The CONTRACTOR shall not proceed with any such aspect of the work until he has received any necessary confirmation, in writing from COMPANY

1.6 UNIT OF MEASUREMENTS

All units of measurement used in drawing and text shall conform to the International System of Units (SI) and Table 1: Units of Measurement.

TABLE 1: UNITS OF MEASUREMENT

Parameter	Unit	Symbol
Distance	Kilometers	km
Length	Meter	m or mm
Elevation	Meter	M or mm
Area	square meter	m^2
Volume, Liquids	Meter cubic/liter	m^3 or liter or kilo lit
Volume, Gases	Meter cubic	m^3 (actual or std)
Liquid Volumetric Flow	Meter cubic/hour, kiloliter/hour	m^3/h or kl/h
Production, Liquid	Barrel per day	BPD
Weight (Mass)	Kilogram	kg
Composition	mole percent	mol %
Liquid Volume Fraction	volume percent	vol %
Mass Concentration	parts per million (molar)	ppm
Mass Flow	kilogram per hour	kg/h
Flow Velocity	meter per second	m/s
Wind Velocity	meters per second	m/s
Density	kilogram/meter cubic	kg/m^3
Liquid Density	degrees API	°API
Viscosity	Centipoises	cP
Pressure (Absolute)	Kilogram/square centimetre	Kg/cm^2
Pressure (Gauge)	Kilogram/square centimetre	Kg/cm^2
Pressure (Vacuum)	Kilogram/square centimetre	Kg/cm^2
Temperature	degree Celcius	°C
Power	Kilowatt	kW or kVA
Heat	Kilo calori	K Cal

Parameter	Unit	Symbol
Pipe Diameter	Inch (nominal)	In
Pipe Wall Thickness	Milimeter	mm
Tubing Sizes	Inch	In
Sound Intensity	Decibel	dB(A)
Level	Milimeter Meter Percentage	mm m %

2.0 ENVIRONMENTAL AND UTILITY DATA

2.1 ENVIRONMENTAL DATA

The system design and selection of materials and equipment shall be suitable for the environmental conditions as follows:

Air temperatur

Maximal	: 35°C
Minimal	: 19°C

Design Humidity

Maximal	: 96.8 %
Average	: 84.6 %
Minimal	: 64.0 %

Rainfall

Daily rainfall maximum	: 45.5 mm

Average of monthly rain fall : 195.3 m/month

Maximum monthly rainfall :300 mm/month occurred in December

Wind

Operating / Normal : 23.0 m/s (3 sec gust)

Design velocity : 35.0 m/s (3 sec gust)

All outdoor instruments and control panels shall be designed to be capable of withstanding the above environmental conditions on a continuous basis.

2.2 UTILITIES DATA

Instrument power supply shall be as follows;

TABLE 2. UTILITIES DATA

POWER	FOR
AC 230 V 50 Hz (UPS)	General Instrumentation including both Local Panels,Fire Alarm System,Tank gauging system.
AC 230 V 50 Hz (1 Phase)	Receptacle, lighting on cabinets and panels. Illuminator for level gauges
AC 400 V 50 Hz (3 Phase)	MOV

Note:

DC 24 V power shall be provided within the system such as Computer Control System etc. from UPS as required. Grounding for instrumentation (instrument earth) shall be less than 2 ohm. Instrument earth shall be separated with power earth.

3.0 DESIGN REQUIREMENTS

3.1 GENERAL

3.1.1 Design Considerations

The instrumentation for measurement and control shall be designed such that optimum operation of the process concerned can be realized at minimum operational and maintenance cost.

The instrumentation and the installation methods shall further be designed for ease of operation, maximum simplicity, reliability and minimum maintenance and safety aspect. Explosion Proof approach shall be used in Design Consideration. Direct connections between process fluids and the control room are not carried out.

3.1.2 Electrical Safety in Explosion Atmospheres

In order to prevent electrical apparatus, including electronic process instrumentation, from becoming a source of ignition in potentially explosive atmospheres, protective measures shall be applied, based on the Hazardous Classification of particular in which the electrical apparatus is being installed.

For such electrical apparatus, the appropriate safety documentation shall be available. Facilities clacified as class 1, Zone 0,

Code of practice for gas atmospheres shall be followed;

- IEC 60079-10 Classification of Hazardous Area
- IEC 60079-14 Electrical Installation in Hazardous Area
- IEC 60529 Ingress Protection (IP) Codes
- API 505 Hazardous Area Classification

a) Selection of Type of Protection

The selection of type of protection shall be in accordance with IEC 60079-14 or its equivalent national or international standards.

The following is the order of preference for the selection of type of protection. Equipment and material selection shall be area classification. As potentialy explosure shall be certified by ATEX.

For Zone '0' areas: Ex 'ia'

For Zone '1' areas: Ex 'd' , Ex 'ia, or Ex 'ib'

b) Environmental Protections

All instruments, systems and related items shall comply with the conditions as specified in the Project Document Bagian B. Persyaratan Teknis Pulau Sambu Fuel Terminal Project.

Plant field mounted instruments shall be suitable for operation in industrial, humid, salt-laden, and corrosive atmospheres. For outdoor locations, the climatic conditions of location class D2 of IEC 60654-1

The minimum degree of protection of field mounted instruments shall be IP 65 as defined in IEC 60529.

3.1.3 Transmitters

The use of transmitters shall for process control and monitoring applications and shutdown service. All transmitters shall be smart electronic transmitters with 2 wire HART protocol dual mode configuration with 4-20 mA outputs and digital signal.

For shutdown service transmitters, both high-high and low-low shutdown signals, where required, will generally be derived from single transmitter, unless the loop criticality rating requires redundant configurations.

Where process control and monitoring transmitters are provided, and where alarms are required, these alarms will generally be derived from the transmitter signal.

3.1.4 Safety Instrumentations

Safety instrumentation shall be designed such that an abnormal condition causes a loss in signal or electrical power. Safety devices and instrumentation shall be capable of being reset without replacement of any element.

3.1.5 Operating Range and Pressure Rating

Normal operating range of an instrument shall be between 20% and 80% of its calibrated range. All instruments shall be rated to system design pressure and shall be suitable for use as per the piping standard.

3.1.6 Lenses

All lenses and windows on instrumentation shall be heavy duty, impact resistant, shatterproof and UV immune.

3.1.7 Proven Equipment

No prototype equipment may be offered and all equipment must have at least two (2) years proven onshore field experience with relevant client recommendations available if required.

3.1.8 Material Requirements

Materials for all wetted parts of in-line instruments shall be in accordance with the requirements of Piping Design and Materials Specification.

3.1.9 Painting

Painting of control valves, safety relief valve, shutdown valve, control panels, etc shall be in accordance with the project Document No. PSFT-WK-SP-40-004-A4 Specification for Shop Painting And Coating and PSFT-WK-SP-40-005-A4 Specification for Field Painting And Coating.

The instruments like transmitters, gauges etc shall be painted as per Manufacturer's standard painting shall be suitable for onshore application.

3.2 INSTRUMENT SELECTION

Instruments shall be selected based on the following requirements:

3.2.1 Instrument Signals

The following instrument signals shall be applied from Table 3: Instrument Signals

TABLE 3: INSTRUMENT SIGNALS

INSTRUMENT	SIGNAL
Electronic Signal	4-20 mA DC, SMART, HART
Pneumatic Signal	3-15 psig
Thermocouple or RTD with Field-installed Electronic Converter	4-20 mA DC
Local Pneumatic Controller	3-15 psig

3.2.2 Scale Selection

Scales shall be selected from Table 4: Instrument Scales

TABLE 4: INSTRUMENT SCALES

PROCESS	SCALE
Flow	0 to 10 square root x Factor or Direct-reading 0 to 100 % uniform
Temperature	Direct-reading 0 to 100 % uniform
Pressure	Direct-reading 0 to 100 % uniform
Level	0 to 100 % uniform
Analyzer & Other Process Measuring	Direct-reading 0 to 100 % uniform

3.2.3 Tubing Selection

Tubing shall be selected from table 5 : Tubing selection

TUBING SIZE	FIELD INSTRUMENT
¼" OD SS316	Control valve
½" OD SS316	Pressure Transmitter, Pressure Differential Transmitter, Pressure Switch
Capillary Tube SS316	Pressure Transmitter, Pressure Differential Transmitter

3.2.4 Range Selection

Instrument ranges shall be selected from Table 6: Instrument Ranges

TABLE 6: INSTRUMENT RANGE

PROCESS	INSTRUMENT RANGE
Flow instrument with uniform	At normal flow rate: within 30 - 80 % of the range
Differential Pressure Flow Instruments	At normal flow rate: within 60 - 90 % of the range
Temperature Instruments	At normal temperature: within 40 - 70 % of the
Pressure Instruments	At normal pressure: within 40 - 70 % of the range
Level Instruments	At normal Level: within 40 - 70 % of the range

3.3 ELECTRIC INSTRUMENTATION

3.3.1 Power Supply and Electric Signal

- Main plant instrumentation should be electronic and contain facilities to communicate with a distributed control system.
- Electronic instrumentation is preferred due to its high reliability, ease of maintenance, and ability to use diagnostics. Digital communication is widely accepted and preferred for new control systems.
- Analog transmitter signals shall be 4–20 mA direct current (DC) and shall be smart type with HART protocol.
- UPS supply available for external power supply to instruments: 230VAC, 50Hz.

3.3.2 Instrument Signal Conventions

The following conventions shall be used for instrumentation signals:

- Smart analog communication shall be considered
- Analog – Hart protocol dual mode configuration 4-20mA and digital signal operating at 24 VDC nominal and two wire field circuit

- Fire and gas detectors – 4-20mA at nominal 24 VDC, two wire circuit. Where two wire circuit is not available three wire shall be used
- Solenoid valves coil rating 1 A at 24 VDC, 3-way, auto reset type
- Alarm signals – Software alarms derived from analog signal or SPDT volt free (dry) contacts rated at 24 VDC, 2A inductive minimum
- For any package of system instrument. Signal transmission, voltage levels and wire system are proprietary of vendor

The following conventions shall be used for operational modes:

- Trip initiation – Software derived trip point from analog signal. When switch is initiating, device contacts shall be designed fail-safe.
- Alarm initiation – Software derived trip point from analog signal. When switch is initiating, device contacts shall be designed fail-safe.
- Fire and gas system solenoid valves – Extinguish release: normally de-energised, energised to operate. Other services: normally energised, de-energised to operate (fail-safe)
- ESD and instrument systems solenoid valves – Normally energised, de-energise to operate (fail-safe)
- Status indication – Closes to indicate running, open to indicate stop. Contacts open to indicate local, close to indicate remote. Contacts open to indicate tripped.
- Motor controls – Contacts open for shutdown. Contacts normally open, closed for nominally 2.5 seconds for start and return open. Contacts normally closed, open for nominally 2.5 seconds for stop and return close.
- The general requirement specified applies to all types of wire and cable unless noted otherwise in this specification.

- All cable outer sheaths shall be able to withstand exposure to environment. Special attention should be given to environmental conditions such as exposure to sea water/salt spray, oil/solvent, UV resistant, excessively high or low ambient temperature, The outer sheath shall be gas/vapour tight and shall have an oxygen index greater than 30.
- Cables used for external installation shall be armoured. Cables routed between control room and field shall be armoured.
- Materials, constructions, and testing of instrumentation and thermocouple cables shall be provided and marked as NEC type PLTC in accordance with UL 13.
- All electrical/instrument cable entries shall be ISO. The minimum electrical/instrument cable entry shall be ISO standard and shall be standardised as far as practical

For detail Instrument Cable Specification (Conductor, Insulation, Insulation Shielding, Armour, Jackets) refer to document, "Instrument Cable & Fiber Optic Specification (Doc. PSFT-WK-SP-60-010-A4)

3.4 INSTRUMENT NUMBERING AND TAGING

- Each item of equipment shall be identified by a unique tag number. The tag numbering system should be in accordance with the project "Piping and Instrument Diagram Legend", document no: PSFT-WK-DWG-10-002-A3
- Individual tag numbers shall be indicated on the engineering flow diagram, piping and instrument diagram (P&ID), or on the mechanical flow diagram.
- Instrument identification tags shall be 316SS. Engraving or die stamp shall include the instrument tag number in numerals at least 3 mm (1/8 in) high. In addition to

permanent tag plate an identification tag plate for field instruments shall be attached with SS wire at least 0.75 mm^2 (AWG 18) diameter.

- Junction boxes, local panels, bulkhead plates, and blind enclosures shall have fixed identification tags. Tags should be of one of the following types:
  1. Phenolic with black lettering on white background, mounted with SS screws or bolts. Lettering should be at least 13 mm (1/2) high, minimum.
  2. Stainless steel with engraving or die stamp lettering at least 13 mm(1/2") high mounted with SS screws or bolts.
- Utilities shall be identified as to service and function at the point of distribution (for example, at power isolating switches and valves).
- Instrument Nameplates

  Following shall be applied for instrument and equipment nameplates:

  a) Panel-Mounted Instruments

  For Panel mounted instruments tag number and service shall be displayed. Black lettering shall be used on a white background.

  b) Field-Mounted Instruments

  A nameplate showing the tag number shall be fixed to the body of each instrument by screws. However, for small instruments, such as thermometer assemblies, pressure gauges, and compact type transmitters, adhesive tape-backed nameplates may be used or the nameplates may be tied to the instruments by stainless steel wire

4.0 FIELD INSTRUMENTATION DESIGN AND SELECTION REQUIREMENTS

Instrument analog signals for electronic instrument systems shall be HART 4 to 20 mA DC. Instrument analog signals for pneumatic instrument systems shall be 3 to 15 psig.

Local control loops will be pneumatic which to be connected to a local panel or will be electronic which to be connected to the control center.

Local indicating controllers shall be furnished with an auto / manual function selector.

All recorders shall be in a control center. Local indicators and alternative controls shall be provided and grouped where local operation may be carried out for operations such as pump control or compressor start-up. Single instruments need not be on a panel, but shall be readily accessible, protected from weather, and located in the areas where the operator normally works.

4.1 PRESSURE INSTRUMENTS

4.1.1 General

Unless otherwise specified, all pressure instruments shall have block and bleed isolation valve arrangements between them and the process block valves. Shutoff and bleed valves shall be provided for each instrument from the process connection. All pressure measuring devices shall have 316 SS wetted parts, unless special materials are required by the process. Performance of instrument shall be of minimum as follow accuracy $\pm$0.15% of span minimum.

4.1.2 Pressure and Differential Pressure Transmitters

a) Electronic pressure transmitters shall be of the HART protocol digital "smart" type.

They shall be capacitive type. Output shall be configurable as digital or as 4-20 mA DC for 0-100 percent-calibrated range.

b) In general, pressure transmitters will not have integral indicators. Where P&ID's require a local indicator for a control loop, the transmitter shall be provided with an integral indicator which shall be readable from the control valve bypass. If the integral indicator is not readable from the control valve bypass, a separate indicator shall be installed remote from the transmitter near the control valve bypass.

c) Pressure transmitter must be equipped with two way valve manifold with process connection 3/4" NPT.

4.1.3 Pressure Switches

a) Pressure switches shall be of the snap-acting type, utilizing two SPDT switches (or one DPDT) rated not less than 4 amps at 24 VDC. All switches shall be field adjustable and shall have a proof pressure of at least 1-1/2 times the maximum operating pressure to which they will be subjected.

b) Pressure switches for direct connected process and utility service shall normally be diaphragm or bourbon tube type with materials suitable for the service.

4.1.4 Pressure Indicator

a) Local process gauges shall be 4-1/2 inches face diameter with lower NPT 1/2-inch connections and blowout backs for personnel protection. When process piping or tubing is smaller than NPS 3/4-inch then 2-1/2 inch face diameter and NPT ¼-inch lower connections are acceptable.

b) Local air signal gauges shall be 2-1/2 inch face diameter with lower or back NPT ¼-inch connections.

c) All gauges shall have a 316SS element and movement. Elements above 1000 psig shall be bored instead of drawn and connections to the socket and tip shall be threaded and welded.

d) Cases for gauges shall be 316SS and weatherproof. All process pressure gauges shall be glycerin liquid filled. This excludes local air signal gauges. Diaphragm seals may be used in lieu of exotic bourdon materials or where required in other process conditions.

e) Sockets and tips shall be stainless steel for stainless steel bourdon tubes and shall be brass for bronze bourdon tubes, according to manufacturer's standards.

f) Overpressure protection shall be 1.5 times the maximum tube rating to prevent permanent set or loss of calibration from continuous overpressures. For services of 0 to 60 psi and below wide bourdon tubes shall be furnished with an external gauge protector to provide this protection.

g) Blowout protection shall be provided on all gauges in process service connected directly to the pressure source. When required, rupture discs or blowout plugs shall be installed on the lower side of the case for local mounted gauges and on the case back for board mounted gauges.

h) Gauge ranges shall be specified so that the gauges normally operate in the middle third of the scale. Gauge ranges on pump discharges shall be specified for over-range protection beyond the pump shut-in pressure or relief valve setting. Gauge ranges on vessels shall be specified for overrange protection not less than 1.2 times the vessel design pressure.

i) For gauges subject to over-range due to process conditions, over-range protection shall be supplied.

j) All direct connected gauges in process service shall be specified for an accuracy of at least 0.5 percent of maximum scale over the entire scale.

k) Diaphragm protectors shall be used where necessary to protect gauges from corrosive fluids or plugging. They shall have ¾ inch NPT screwed or flanged connections according to piping specifications.

l) Siphons shall be provided on hot vapor service and all steam services to minimize the heat conducted to the pressure element.

4.2 TEMPERATURE INSTRUMENTS

4.2. 1 General

a) All process temperature sensing instruments shall be furnished with thermowells.

b) Thermowell and temperature sensor shall be designed together to ensure compatibility in size, material, rating etc.

c) Spans for temperature control shall be as narrow as consistent with process requirements.

d) Controllers shall have a minimum of proportional and integral band adjustment.

e) The selection of temperature instruments will be based on the following consideration:

- Two wire system
- Smart type
- Accuracy which is not worse than 0.15 % of span
- Response time which is not more than 400 ms
- Automatic zero and span adjustment
- Maximum reliability of system performance including dynamic performance for a certain period of time
- Stability is not worse than +/-0.5 % drift for 3 years of URL
- Power supply effect that is not more than 0.005 % of span per volt

- Built up with surge protection
- Self calibration capability
- LCD display availability requirement

4.2.2 Thermowells

a) Temperature wells for general application thermocouples, resistance elements, bimetallic thermometers and temperature test services shall be constructed for inter-changeability for all standard applications. Thermowells shall be capable of withstanding the process temperature and pressure.

b) Installation of thermocouples, thermowells, test wells, and thermometers shall be where there is flow and rapid response and shall be coordinated with piping design. In vessels having a liquid-vapour interface, thermowells shall be installed in the liquid phase. Thermowells in combining streams shall be a minimum of 10 pipe diameters downstream of the junction for liquid services and 30 pipe diameters downstream of the junction for vapour services. Thermowells in all vapour streams shall have wake frequency calculation.

4.2.3 Temperature Indicators

a) Temperature indicators (TI) shall be bi-metallic, hermetically sealed, heavy duty, every angle with zero calibration adjustment, dial-type thermometers. The TI stem shall be ¼" and the stem length shall be as required by the mating thermowell. The stem shall have a ½" NPT connection. Dial size shall be 5" minimum. The range shall be selected

so that it is normally a manufacturer standard range, and the normal operating temperature shall be in the middle third of the range.

b) All temperature indicators shall be located and oriented such that they are easily visible from aisles and areaways used in normal operation.

4.2.4 Temperature Sensors

a) Temperature sensors shall be furnished as complete assemblies, including the measuring elements, terminal heads, and thermowells or protecting tubes. Elements (bimetal, RTD, thermocouple etc.) shall be spring-loaded style to firmly contact the bottom of the thermowell. Identification of each temperature element shall be by a wired on metal tag indicating the tag number.

b) RTD elements shall be the 3-wire type and shall be connected to measuring instruments by three-wire cables.

c) With exception of rotating equipment temperature monitoring, RTD's shall be installed with 4-20 mA DC instruments.

d) Thermoelectric properties, temperature limits, and limits of error of thermocouples and thermocouple extension wires shall conform to ANSI standard MC96.1. Length shall not less than 12".

e) Thermocouples for general application shall be type "K" chromel-alumel (Range Temperature 800 to 200 °F). Other thermocouple types may be used for extremely high or low temperatures or special atmospheres. Thermocouples shall be magnesium oxide insulated sheathed type. The hot junction shall be grounded to the sheath. Thermocouples shall be constructed with a 316SS or Inconel sheath of ¼" diameter.

4.2.5 Temperature Transmitters

a) Electronic temperature transmitters shall be of the HART protocol digital "smart" type. They shall be equipped with ambient temperature compensation. Output shall be configurable as digital or as 4-20 mA DC for 0-100 percent-calibrated range. Spans for temperature control shall be as narrow as is consistent with process requirements. Electronic transmitters shall be furnished in an enclosure suitable for the electrical area classification. Externally adjustable span and zero shall be provided.

b) In general, temperature transmitters will not have integral indication. Where P&ID's require a local indicator for a control loop, the transmitter shall be provided with an integral indicator which shall be readable from the control valve bypass. If the integral indicator is not readable from the control valve bypass, a separate indicator shall be installed remote from the transmitter near the control valve bypass.

4.3 LEVEL INSTRUMENTS

4.3.1 General

a) Where possible, common vessel connections with a minimum of 2" ANSI flanges shall be used for multiple level instrument installations.

b) Liquid level instruments shall be accessible from deck level or an access platform and shall be rigidly supported.

c) Level instruments shall be installed a sufficient distance from outlet connections to prevent the outlet stream from affecting the instrument operation.

4.3.2 Level Gauges

a) Gauge glasses shall be steel armoured reflex or transparent type. Reflex gauges shall be used for all clean process and utility services. Transparent gauge glasses are to be used on interface service and on acid, caustic dirty fluids.

b) Tubular gauge glasses shall not be used except for atmospheric services such as lube oil reservoirs or jacket water service.

c) Gauge glasses, including Magnet Float Type, shall generally be applied adequately where the local indication only required.

d) Gauge glasses shall wherever possible be arranged to provide indication over the full range of level transmitters, level controllers or level switches.

e) All gauge glasses must have a rating equal to or greater than the vessel design pressure and temperature. Gauge glasses shall be stamped with their maximum pressure/temperature rating.

f) Gauge glasses shall be furnished with ¾ inch RF Flange tank connections, gauge cocks with safety ball check valves, ½ inch NPT vent and drain connections with plugs. Vent and drain valves shall be provided.

g) Mica or other protective material shall be specified if the fluid will attack glass e.g. caustic.

h) Gauge glasses shall generally be limited to four sections but for service 392°F or higher, gauge glasses shall be limited to three sections maximum. Where two or more gauge glasses are required to provide necessary coverage the visible glass shall overlap approximately 1 Inch. Normally where multiple gauge glasses are required, a strong back (gauge column) shall be provided.

i) Strong backs may be installed on horizontal drums, columns or exchanger

when required for structural support for gauge glasses or level instruments. Strong backs shall be 2" or 3" Sch 80 pipe (min) with flanged end connections. Over or under gauge glass installations shall be adequately braced to reduce stress.

j) Strong back shall be oriented so that gauge glasses are conveniently visible and accessible from walkways, platforms, stairways or ladders for maintenance.

k) Gauge glasses shall be specified in the visible length and center to center dimension wherever practical.

4.3.3 Level Switches

a) The Mechanical Float Type level switches shall be applied. Level switches shall be field adjustable and shall be used for both high and low applications, if required by the P&ID's. See "Alarm Switches" section. The wetted parts shall be made of 316 SS as a minimum.

b) For Mechanical Float Type switches, the displacers of cage mounted LSHH shall be of 304LSS or acrylic material, unless specified otherwise by Company. Other materials may be required due to special process conditions. The float arms shall be 316SS. All high switches (LSHH for product tank) shall have 4" flanged top process connections, unless specified otherwise by Company. High and low liquid level switches shall be external cage snap-acting switches, and shall be installed with isolating, vent, and drain valves. Unless specified otherwise on the P&ID's, the safety sensors shall be installed on level bridles along with their corresponding level gauge so that they are all easily visible from the operating aisle.

c) For magnetic level gauge units, with switches, see "Level Gauges" section. Level switch and transmitter functions shall be included with the magnetic level gauges if shown on the P&ID's. The switch and transmitter units shall meet the same enclosure design, signal requirements and electrical area classification defined for other types of level switches and transmitters.

d) Electrical level switches shall be furnished with an enclosure appropriate for the electrical area classification. Contacts shall be DPDT. Set points shall be field adjustable. Switches utilizing mercury-wetted contacts shall not be used. Explosion proof housings or hermetically sealed dry contact switches are to be used for all services in hazard classified areas. On low energy circuits, low resistance contacts shall be provided.

4.4 FLOW INSTRUMENTS

Standard and specification for metering system refer to American Petroleum Institute (last edition) :

a. "Manual of Petroleum Measurement Standards Chapter 4 - Proving System"

b. "Manual of Petroleum Measurement Standards Chapter 5 - Liquid Metering" :

- Section 6 : Measurement of Liquid Hydrocarbons by Coriolis Meter
- Section 4 : Accessories Equipment for Liquid Meters

c. Regulations PT PERTAMINA (PERSERO) and Ditjen MIGAS.

General

The Flow Measurement System shall be basically configured without comparing among any flow meter in order to prevent any discrepancies depended on that

there are several accuracy on each meter. The transaction meter shall only be able to be compared with the Master Meter.

Positive Displacement Type or Turbin Meter

The Positive Displacement Type or Turbine Meter shall generally be used where a high degree of accuracy and wide rangeability are required as custody transfer line or pump control service. The material of the internal parts wetted shall be selected suitably depending on the process fluid.

4.5 CONTROL VALVES

All pneumatic control valves shall be fitted with electro-pneumatic positioner. The I/P positioner shall be smart type based on HART Protocol.

Control Valves and/or Pressure Regulators shall be sized to pass at least 120% of anticipated maximum flow rate at the permissible pressure drop for the flow rate. Control Valves shall be actuated by the Pneumatic System or Hydraulic System. The Pressure Regulator shall be of self-regulating type.

Noise levels for Control Valves shall not exceed 85 dB at one meter downstream or from the pipe.

Control valve have criteria ' Fail safe ' to concerns the failure of the signal and the air supply, as indicated in P & ID such as the Fail Open/Fail Closed. Installation of the control valve should be provided with the manual by pass valve as shown on P&ID. Isolation valve should be provided for the control valve on the side of upstream and downstream with ¾" drain valve.

4.6 PRESSURE RELIEVING DEVICES

4.6.1 Sizing and Selection

All pressure relieving devices shall be sized in strict accordance with applicable local, state, and national code requirements. Safety relief valves shall be sized by calculating ASME areas required for the most severe relieving case and shall follow the ASME requirements. Nomenclature and formulas used shall be according to API RP 520. Valve selection and installation shall be based on API RP 520, Part I and Part II. Closed relief valve discharge systems shall be designed in accordance with API RP 521.

4.6.2 Pressure Safety Valves Sizing and Selection

- Pressure safety valves for unfired equipment shall be sized in accordance with API RP 520 and the ASME Pressure Vessel Code, Section VIII.
- Rupture Discs may be used instead of or in combination with safety and relief valves where applicable or required. When rupture discs are used in combination with relief valves, they shall be purchased as a system with the relief valve.
- The relief pressure shall be no greater than 125% of the maximum operating pressure of the vessel or pipe or less if required by any Codes.
- Modulating pressure relief valve is used for steam and its setting pressure is 15% above maximum injection pressure.
- Safety valves for steam turbine casings shall be sized according to NEMA Standards Publication Number SM23, when full relief is required. Condensing steam turbine casings shall normally be equipped with full-flow relief valves of the atmospheric type. Non-condensing steam turbine casings shall normally be equipped with relief valves of the sentinel type

for warning purposes only; unless the turbine starts automatically or is a multistage turbine, then a full-flow relief valve is required.

- Percent accumulation used in calculating sizes of relieving devices shall be as follows:
  - 3 percent: Steam service according to ASME Code, Section 1.
  - 10 percent: Gas or vapor service and liquids except as noted below.
  - 10 percent : Liquids - for thermal relief of pipelines and pump discharges, if code stamped valves are not required in all services
  - 16 percent: Vessels protected by multiple valves according to ASME Code, Section VIII. However, one valve must be set at or below the MAWP (Maximum Allowable Working Pressure) and the additional devices may be set to open at higher pressure, but not exceeding 105 percent of MAWP.
  - 21 percent: Vapor and liquid service in areas governed by fire conditions according to ASME Code, Section VIII.

- Safety and relief valves shall normally be direct spring loaded balanced bellows valves shall be considered for closed flare and blow-down systems or elsewhere if back pressure may be present. Pilot operated valves shall be considered if operating pressures are close to set pressures. Other types of valves may be considered for special applications.
- Connection sizes and ratings shall normally be as follows :
  - Flanged connections shall normally be furnished on all safety and relief valves 1 inch and larger. The minimum rating shall be ANSI 150 class. Valve flanges shall match the rating and facing of mating flanges on vessels or piping. Body flanges shall be per ANSI B16.5.

- Screwed connections may be furnished on valves NPS ¾-inch and smaller, unless process or operating conditions do not allow. Threaded connections shall be per ANSI B2.1.

- Steel bodies with stainless steel trim shall normally be specified. Alloy bodies or special materials shall be specified where required because of process, atmospheric or operating conditions.
- When ASME code stamp relief valves (relief valves to which the code symbol is applied) are required, they shall be fabricated by a manufacturer who is in possession of a code symbol stamp and a valid Certificate of Authorization from the ASME Boiler and Pressure Vessel Committee.
- Full nozzle valves shall normally be specified for NPS 1 inch and larger.
- Materials of construction shall normally be governed by the appropriate piping specification generally as follow:
  - Steel bodies with stainless steel trim shall normally be specified.
  - Bronze bodies shall normally be specified for thermal relief in cooling water service and air service, provided piping specifications permit.
  - Springs shall be carbon steel for normal process operating temperatures of minus 20 degrees F through 450 degrees F, tungsten alloy steel or inconel above 450 degrees F, unless other material are required by the process.
  - Graphite or satellite is used for plug and seat of pilot steam pressure relief valve.
  - Valve plug & seat are 316 SS for steam pressure relief valve.
  - Valve O ring and Seal shall be teflon.
- Plain closed bonnets shall normally be specified with a tapped and plugged vent.

- Pressure and vacuum relief valves for storage tanks shall normally be of the weight loaded or pilot operated type, and sized according to API Standard 620 and API Standard 2000.
- Isolation and sparing of the relief device may be provided for maintenance as shown on P&ID. All the isolation valves shall be full bore, suitable for line service classification and have the capability of being locked or car sealed open.
- Set pressure tolerances shall comply with ASME Code, Section V111, or ASME Code, Section I as applicable.
- Seat Tightness

  Metal-to-metal seats shall normally be specified as Commercial tightness, which permits a stipulated maximum leakage at a specified percent of set pressure. Bubble tightness, which permits no leakage at specified percent of set pressure, shall be specified when required by process conditions or customer requests. Testing for tightness shall be required to be according to API RP -527.

  Safety relief valves selection, sizing and installation shall fully comply with the latest edition of the API RP 520 Standard.

4.7 MOTOR OPERATED VALVE

Valve complete with its driving motor (MOV) be used to flow the fuel. It purpose to be operated automatically controlled from control room. All motors for pumps start from local or remote from Central Control Room used Variable Speed Drive. The Motor Operating Valve (MOV) System shall be constituted with MOV and the Master Station which controls all MOV through the communication system. The

communication shall have the redundant system and the signals shall be able to be communicated with the DCS at MCR.

4.8 ALARM UNIT AND SHUTDOWN SWITCHES

Switches and shutdowns for alarms and interlock systems shall be used for on/off applications only when transmitters are not available for the same applications. Use of switches is discouraged. If they are used, the following guidelines apply.

When outdoor installations are required, they shall be suitable for Zone 2, Group II, T3 Temperature Classification T3 as a minimum.

Wiring for switches shall be two-conductor and shall not use the common wire technique.

Switch contacts shall be specified double-pole double-throw wherever possible for versatility. However, only one function for each enclosure shall be specified (for example, alarm only, or interlock only). On shutdown circuits, the second contact on the enclosure may be used for alarm but proper signal separation shall be maintained in the cable system.

The contact rating shall be 2 Amp @ 24 VDC. For switches associated with high input impedance low current devices such as TAS, low resistance contact (gold plated) shall be provided. Contacts shall normally be specified for 230 V, 50 Hz for instrument services and 400 V, 50 Hz when used to operate motors and other heavy duty electrical devices.

Switch action for alarms, shutdowns, and interlocks shall normally be closed circuit at normal operating conditions; open circuit for abnormal condition.

Typical process switches shall follow these general specifications:

- Flow switches for direct operation by process fluids may be of the sight flow, rotameter, or paddle type for low accuracy requirements. Orifice plate and differential pressure type switch or thermal dispersion switches shall be used for high accuracy requirements.

- Level switches shall be attached to the magnetic level gauge units or the external float cages with 1/2" NPT screwed cable connections. Body material and rating shall conform to piping specifications. Internal trim shall be stainless steel unless other materials are required for the service.

- Pressure switches shall have piston, bourdon tube, or welded diaphragm type elements. Final element type selection shall be approved by Company.

- Temperature switches shall normally be mounted in the control room or on a local panel and be actuated by a thermocouple or RTD. Thermocouple switches shall have cold-junction compensation.

5.0 DESIGN CRITERIA OF INSTRUMENTATION SYSTEM

Design of Instrumentation and Control system at Pulau Sambu Fuel Terminal project consist of Terminal Automation system, tank gauging system, motor control for pumps, emergency shutdown system, metering system, CCTV, and fire alarm system. Detail of control system at this project are to control product with MOV, control pumps, control and monitoring condition of product, tank management system, ESD system, and data management system.

Application of control system at Terminal Automation system are :

a. Loading and unloading
b. Storage
c. Distribution
d. Inventory
e. Emergency shutdown

6.0 JUNCTION BOX

Junction Box shall be designed to be corrosion resistant and weather proof to NEMA 4X or IP 66 and certified for Hazardous area classification.

A minimum of safety "Ex e" type with protection degree NEMA 4X or IP 66 for outdoor non hazardous area (safe areas).

The junction box and/or the components and instruments in the panel shall be certified suitable for the hazardous area classification.

Air purging to obtain certification shall not be acceptable unless approved by COMPANY.

Junction boxes shall be robust and capable of withstanding pullout cable load. Junction boxes shall be made of stainless steel or Aluminum Die Casting and suitable for outdoor use.

The material shall be made of corrosion proof or a corrosion proof painting and coating system shall be applied, if painting and coating system is used. It shall comply with international standards and codes.

APPENDIX – 1. CONNECTION TO PIPING

INSTRUMENTS	TYPE AND SIZE OF CONNECTION	TYPE AND SIZE OF BLOCK VALVE
Temperature -Flange	1 1/2" Flange	None
Pressure Instruments: - Normal - Diaphragm Seal	3/4" Flange or Screw 3/4" Flange or Screw	3/4" Ball Valve 3/4" Ball Valve
Differential Pressure Instruments: - Normal - Diaphragm Seal	3/4" Flange or Screw 3/4" Flange or Screw	3/4" Ball Valve 3/4" Ball Valve
Pressure Indicator - Normal - Diaphragm seal	3/4" Flange or Screw 3/4" Flange or Screw	3/4" Ball Valve 1/2 " Ball Valve 3/4" Ball Valve

APPENDIX – 2. CONNECTION TO EQUIPMENT

INSTRUMENT	TYPE AND SIZE OF CONNECTION	TYPE AND SIZE OF BLOCK VALVE
Temperature -Flange -Multi Point	 2" Flange to Tank or vessel 4" Flange to Tank	 None
Pressure Instruments - Normal - Diaphragm seal	 2" Flange	 Gate Valve
Pressure Differential - Diaphragm seal - Normal	 None	 None
Top Mounting Level Instruments - Displacers(servo) - Radar - Ultrasonic	 6" Flange 8" Flange 3" Flange	 c/w Calibration chamber None None
Side Mounting Level Transmitter - DP Level Transmitter	 2" Flange	 2" Gate Valve
Gauge Glasses - Directly Mounted on Equipment - Stand Pipe Mounted	 3/4" Flange	 3/4" Gate Valve

PT PERTAMINA (PERSERO)
APPROVED ENG
APPROVED WITH COMMENT
NOT APPROVED
DATE | CHECKED | APPROVED

CLIENT : PT PERTAMINA (PERSERO)

CONTRACTOR : PT. WIJAYA KARYA (PERSERO)

PROJECT NAME : PENGEMBANGAN TERMINAL BBM PULAU SAMBU

LOCATION : PULAU SAMBU, RIAU ISLANDS, INDONESIA

CONTRACT NO. :

PERTAMINA
FOR CONSTRUCTION
Sign : Date : 16-12-14

REV.	DATE	DESC.	PRE'D	CHECKED	APPROVED	CHECKED	APPROVED	APPROVED
			PT.WIJAYA KARYA			PT.AUDEX INDONESIA		PT.PERTAMINA
1	11 Jul '14	Issued For Approved	NVR/KA	DA/NKM	ADW			
0	24 Mar '14	Issued For Review	NVR/KA	DA/NKM	ADW			

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REVISION SHEET

No.	Revision	Date	Description
1.	1	11 Juli 2014	a. Added information about Butterfly Valves and Ball Valves b. Added description about Valve Sizing & Valve Positioners c. Added information about Hand wheels d. Added description about Limit Stops & Volume Boosters e. Added description about Inspection, Testing, Commisioning & Approvals f. Added information about limit switch and power supply. g. Added information about power supply of Instrument Signal h. Added information about limit switches

1.0 INTRODUCTION

1.1 GENERAL

PT. PERTAMINA plans to make refurbishment on Pulau Sambu Fuel Terminal At Pulau Sambu, Riau Islands, Indonesia. The scope of work comprises of detail design engineering, procurements, construction, testing and pre-commission of the modification existing storage tank, additional storage tank facilities, pumping station facilities, piping for new product and blending system.

1.2 SCOPE

This specification covers the general requirement of Control Valve and all specified accessories suitable to be used in Pulau Sambu Fuel Terminal Project. The scope of work for the control valve shall include, but not be limited to, the design, purchase, testing, and provision of documentation, manuals and engineering software in accordance with the project requirements.

1.3 DEFINITIONS AND ABBREVIATIONS

Definitions

COMPANY	: This shall mean PT. PERTAMINA (PERSERO)
CONTRACTOR	:The Company of Engineering, Procurement, and Construction, This shall mean PT.WIJAYA KARYA (PERSERO) TBK
VENDOR	: The supplier, manufacture or the owner of material and equipment, chosen by the COMPANY or proposed by the CONTRACTOR and approval by the COMPANY.

Abbreviations

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society of Mechanical Engineers
IEC	International Electro-technical Commission
ISO	International Standard Organisation
P&ID	Piping and Instrumentation Diagram
PLC	Programmable Logic Controller
UCP	Unit Control Panel

1.4 REFERENCES, CODES AND STANDARDS

The following codes shall be interpreted as the minimum requirements applicable to the subject work, and no statement contained in this specification shall be construed as limiting the work to such minimum requirements.

(API) American Petroleum Institute

API RP 551	Process Measurement Instrumentation
API STD 598	Valve Inspection and Testing
API 607	Fire Test for Soft-Seated Quarter-Turn Valves
API 6FA	Specification for Fire Test for Valves

(ANSI) American National Standard Institute

ANSI/FCI 70.2	Control Valve Seat Leakage Classifications

ASME (American Society of Mechanical Engineers)

Sect. II,	Material Specification
ASME B 16.3	Valves-Flanged, Threaded and Welded

ASME B 16.5	Pipe Flanges and Flanged Fittings (NPS ½ through NPS 24)
ASMEB16.10	Face to Face and End to End Dimensions of Valves
ASMEB16.34	Valves-Flanged, Threaded and Welded End
ASMEB16.4	Large Diameter Steel Flanges: NPS 26 through NPS 60

ASTM (American Society for Testing and Materials

EN 61236	Electrical equipment for measurement, control and laboratory use. EMC requirements

British Standard (BS)

BS 6364	Valves for Cryogenic Service

IEC (International Electrotechnical Commission)

IEC 60529	Degree of Protection Provided by Enclosures (IP Code)
IEC 60770-1	Transmitters for Use in Industrial Process Control System Part 1– Method for Performance Evaluation

International Society of Automation (ISA)

ISA S75.0	Flow Equation for Sizing Control Valves
ISA S75.03	Face to Face Dimensions for Integral Flanged Globe-Style Control Valve Bodies (ANSI Classes 125,150, 300 and 600)

ISA S75.05	Control Valve Terminology
ISA S75.15	Face to Face Dimensions for Butt-weld-End Globe-Style Control Valve Bodies (ANSI Classes 125,150, 300 and 600)
ISA S75.17	Control Valve Aerodynamic Noise Prediction
ISA S75.19	Hydrostatic Testing of Control Valves
ISA S75.22	Face to Centreline Dimensions for Flanged Globe-Style Angle Control Valve Bodies (ANSI Classes 150, 300)

1.5 CONFLICTING REQUIREMENTS

In the event of conflicts between this specification and the above listed applicable regulations, codes and standards, all apparent conflicts shall be reported to COMPANY for resolution, the following order of precedence shall be followed:

1. Indonesian Codes & Regulations (if any)
2. Technical Requisition including functional specification and data sheets
3. This specification
4. Other project specification
5. International codes and standards

Compliance with the statutory requirements of the Indonesian Authorities is Mandatory. It shall be the CONTRACTOR responsibility to raise to COMPANY any discrepancy between documents. The CONTRACTOR shall not proceed with any such aspect of the work until he has received any necessary confirmation, in writing from COMPANY.

2.0 GENERAL REQUIREMENTS

2.1 ENVIRONMENTAL DATA

The system design and selection of materials and equipment shall be suitable for the environmental conditions as follows:

Air temperature

Maximal	: 35°C
Minimal	: 19°C

Relative Humidity

Maximal	: 96.8 %
Average	: 84.6 %
Minimal	: 64.0 %

Rainfall

Daily rainfall maximum	: 45.5 mm
Average of monthly rain fall	: 195.3 m/month
Maximum monthly rainfall	: 300 mm/month occurred in December
Total of annual rainfall	: 2344 mm / month

Wind Conditions

Operating / Normal	: 23.0 m/s (3 sec gust)
Non-Operating / Extreme	: 35.0 m/s (3 sec gust)

2.2 ENCLOSURE OF INSTRUMENT

The enclosure of all field electric/electronic instruments provides a degree of protection equivalent to IP 65.

2.3 INSTRUMENT SIGNAL

Unless otherwise specified individually, the following standard instrument signals shall be applied:

- Electric : 4-20 mA DC.
- Pneumatic : 0.2 -1 kg/cm2 (3-15 psig).
- Power Supply : 24 VDC

3.0 DESIGN OF CONTROL VALVE

3.1 SELECTION OF CONTROL VALVES

Top and Bottom Guided or Balanced Cage Trim Globe, or Characterized Ball shall be used. Trim shall be replaceable from the top of globe types.

3.1.1 Control Valve Characteristics

The type of control valve trim shall be specified to the required flow characteristic for the duty i.e. quick opening, linear or equal percentage.

a. An adequate allocation of pressure drop across the control valve, in conjunction with the selected characteristic, should be applied to ensure a near linear relationship between valve position and the controlled variable over the entire operating range.

b. When approximately 50% or more of the dynamic pressure drop is allocated to the control valve, the valve should have a linear characteristic; otherwise it should be fitted with equal percentage 1rim. Also linear characteristic should be applied to a three-way control valve and severe service, e.g. compressor anti-surge control.

c. The use of quick opening trims in control valves shall be subject to approval by Company.

3.1.2 Level Instrument

All control valves shall be sized to provide adequate rangeability at minimum cost. A control valve shall be selected such that its capacity is greater than 120% to 140% of normal/maximum operating condition for linear trim and 130% to 160% for equal percentage trim, as a rule.

The effect of any reduced inlet and outlet pipe sizes and valve pressure recovery shall be taken into account when sizing control valves. Control valves should be designed to operate within the limits of 10% to 90% of their stroke at normal operating condition, as a rule. Where the control required is very low lift less than Vendor's minimum lifts recommendation, another smaller valve shall be required. Then, two valves in parallel may be used.

Control valves shall be sized according to ISA S75.01 or an approved manufacturer's calculation program.

3.1.3 Valve Noise

The predicted sound level of control valves should not exceed 85 dBA at a position 1 meter downstream from them and 1 meter from the pipe surface under normal process conditions.

Noise calculations shall comply with ISA standards or an approved Vendor standard calculation.

When noise is due to exceptional permanent process condition, deviation shall be considered with agreement of Company.

The maximum calculated noise level shall be obtained without the use of orifice, diffuser and/or credit for thermal or acoustic insulation.

Control valves with special trim for noise reduction should have globe, angle or ball bodies and cage trims.

3.1.4 Cavitation and Flashing

The Vendor shall guarantee that cavitations and flashing is eliminated to such a point that the control valve may operate stable without repair for a period of 12 months.

When flashing conditions cannot be avoided, or are desired, the control valve shall be installed as close as practicable to the vessel into which the flow media is being discharged.

3.1.5 Seat Leakage

If a TSO (tight shut off) performance is not required for control valves, such as in the P&ID's, or control valve specification sheets, etc., ANSI/FCI-70.2 class IV seats leakage class shall be applied unless otherwise specified.

Double seated valves are not recommended for tight shut-off services.

3.1.6 Action of Control Valve

The required action of each valve on failure of its control signal or operating medium shall be specified; with due regard to safe operation and shut down. Failure position shall be indicated on P&ID's and data sheets.

3.1.7 Types of Control Valve

The type of control valve shall be specified to satisfy the process conditions. Generally, control valves of globe, butterfly, ball, or eccentric rotating plug design shall be employed. All other valve types shall be subject to approval by Company.

a. Globe Valves

In general, single seated or double seated type globe valves (linear motion) shall be used for all services. The use of cage-guided globe valves should be avoided in those applications where the fluid may contain solid particles or may form a coke.

b. Butterfly Valves

Butterfly valves shall be considered in the following situations and if economically attractive:

- A high flow rate with a low pressure drop
- The maximum pressure drop across the valve is lower than the limit specified in the valve manufacturer's standard
- For corrosive services where a body lining is required
- Butterfly valves shall be of the heavy duty wafer type with external roller bearings and lubricated packing.

- The shaft and wafer shall be sized for a pressure drop equivalent to twice the maximum upstream pressure.
- In throttling services, butterfly control valve shall have 100% CV with a 60° opening under maximum flow conditions. The use of special wafers allowing full control at highes angles of opening shall be subject to contractor / company approval.

c. Ball Valves

- Ball Valve used on throttling services, on/ off valves where frequent operation occurs or where temperature and pressure fluctuatives of the process fluid occurs shall have metal seat. Where particular matter is suspended or entrained in the process fluid and tight shutoff is required, scraper action with spring loaded seats shall be specified.
- Soft seats may be specified for infrequent on/off operation on clean services, at temperature below 250° F (120° C) and (120° C) and where the process temperature and pressure is considered to be constant.
- Ball valves shall have a body rating conforming to the piping class, but shall be a minimum of ANSI class 300 for sizes up to including 16 inch. For larger sizes ANSI class 150 may be specified if this is in accordance with piping class.
- Ball type valves shall be considered especially for on-off services. Large volume flows and high shut-off differential pressures may be controlled by full-bore ball valves or characterised ball valves. The minimum size of globe and ball valve bodies shall be NPS 1 (DN 25).

d. Regulators

Direct-operated regulators shall be considered for simple, non-critical applications where normally no operator intervention is required and, preferably, clean fluids are handled.

These include for a pilot fuel supply of the furnace, atmospheric vessel, and gas blanketing application.

e. Others

Other types of control valves, such as parallel slide valves (gate valves), split-body valves, and diaphragm valves may be considered for such applications where they are economic and technically advantageous.

Special design considerations are required when using low-noise valves and anti-cavitation valves. Such design should be always made in consultation with the valve manufacturer.

3.2 VALVE CONSTRUCTION AND MATERIAS

Control valves with soft seats (such as PTFE) shall only be employed where the specified degree of tight shut off cannot be achieved using metal seats. However pressure and temperature rating of the soft seats shall be rated up to design temperature specified in the valve data sheet at detailed engineering phase. Vendor/manufacturer shall submit soft seat pressure and temperature rating chart for the design temperature specified.

Butterfly valves should be provided with stainless steel vanes and shafts of precipitation hardened materials.

Where 'Through Body Bolted Control Valves' are considered for use, the following criteria should be taken into account.

a. The length of the bolts concerned. (The potential for misalignment or leakage with butterfly valves for example is not as great as for valves of significantly greater face to face dimension).
b. The duty of the pipeline and control valve concerned together with the line size. Great care should be taken when considering 'Through Body Bolted Control Valves' for Hydrocarbon service and in particular where the line size is large.
c. The fire risk in the immediate area of where the control valve is to be sited and what type of fire protection is available.

3.2.1 Body Assembly

Control valves body and bonnet material shall be in accordance with piping service class. However, alternative material equal or superior to that specified, may be substituted if it meets internationally recognized standards.

The material of the valve trim (usually consisting of plug, seat rings and stem) shall be at least 304 or 316 stainless steel unless process conditions require other materials.

Hardened trim materials shall be considered for severe services, such as high-pressure steam, a high pressure drop across the valve, erosive service, cavitating and flashing service, etc. according to the valve manufacturer's recommendation.

Bonnets other than a standard construction (extension or fins) shall be provided in accordance with the valve manufacturer's recommendation.

1", 1½", 3", 4", 6", 8", 12", 20", valve sizes are to be used. The face-to-face and end to end dimensions on flanged and butt-welding ends valves shall comply with ASME B16.10. Special valve designs which do not conform should be noted. 1¼", 2½", 3½" and 5" will not be used.

End connections of control valves shall be of flanged type and its rating shall be in accordance with piping service class. For butterfly valves, wafer type is acceptable. Applicable standard code for flange dimensions shall be as below:

Flange Size	Standard
24" or smaller	ASME B 16.5
26" to 60"	ASMEB16.47 series B

3.2.2 Indication of Flow Direction

"Flow direction" as per P&IDs shall be shown on control valve specification, vendor drawing and valve body itself clearly. By rivets or screws in the form of a casting, stamping or permanently attached plate.

The body gasket shall be according to the valve manufacturer's standard provided that it is suitable for the process conditions specified.

Packing shall not contain asbestos and shall be either PTFE-based or graphite-based in accordance with the manufacturer's recommendation for the specified temperature limitation.

The use of block and by-pass valves shall be determined by P&ID review.

3.3 ACTUATOR

The actuator shall be designed to open and close within the stroke time necessitated by process requirement and to satisfy the specified seat leakage performance.

Pneumatic spring-opposed diaphragm or piston actuators are preferred, and shall be designed for full functionality at minimum instrument supply air pressure at 60 psig unless otherwise specified.

Double acting actuator, piston type can be used for specific cases, where single acting actuators are not suitable. Piston actuators may be used for high force outputs.

Piston actuators are to be sized to supply the specified force using no more than 60 psig air, but must be suitable for pressures up to 125 psig.

The construction shall be leak-tight, with seal gaskets. Piston or cylinder actuators shall have O-ring sealing and shall be designed to minimize shaft and piston friction.

Where necessary, a hydraulic actuating system in lieu of air may be used. If hydraulic valves are selected, following equipment shall be equipped. Hydraulic power pack unit completes with the electric pump shall be provided, which must conform to the electrical area specification. Supply of actuating fluid shall be equipped with secure backup reservoir system and be protected as necessary against potential hazards.

For large size valve, which requires large torque, the application of double acting air cylinder type or hydraulic type, etc. shall be investigated with consideration of constructability and maintainability.

Where double acting air cylinder or hydraulic valves will be applied, an air volume tank or hydraulic accumulators sized to provide an independent air or hydraulic supply for at least three (3) strokes, i.e. for failure close valve; open-close-open-close, for failure open valve; close-open-close-open, and to provide motive energy to move the valve to its fail safe position. However, if air failure lock will be specified, no volume tank will be required.

Design of the air volume tanks shall be subjected to ASME code; strength calculation shall be made for the air volume tanks in accordance with ASME code, however ASME stamp is not required.

The required fail position of the valve shall be determined by analysis of the process. It may be "Fail Open", "Fail Closed", "Fail Locked" or "Fail Indeterminate". Actuator failure mode must accomplish the valve positions. When fail locked position is selected, the valve action in case of signal failure shall be specified.

Electrical powered actuators may be selected for on - off isolation butterfly or ball valves etc., and subject to Company's approval. The actuator must conform to the electrical area classification as shown on the data sheet. The electrical power supply shall conform to electrical requirements.

Electric motor actuators should be mounted so that the motor is above the gearbox, to prevent gear oil from saturating the motor windings.

3.3.1 Actuator Sizing

The actuator shall be suitably designed to operate open and close, and to satisfy the specified seat leakage performance under all the conditions.

Actuators (diaphragm and piston) shall be sized for positioning the inner valve against 1.25 times the maximum differential pressure that may develop under normal or start-up operation.

The maximum process differential pressure used for actuator sizing should be the difference between atmospheric pressure and the maximum upstream pressure with the valve fully closed, unless otherwise specified.

3.3.2 Construction and Materials

Actuator materials shall be the manufacturer's standard and shall be suitable for the specified environmental conditions.

3.3.3 Valve Sizing

Control valves shall sized based on the data in the data sheets, The sizing calculations shall be accordance with ISA S75.01 or IEC 534 Part 2 and Part 2/2.

Intermediate capacity indexes or steam position shall be deried.

The results of calculations, together with selected valve type and discharge coefficient, shall be submitted to the Contractor / Company for approval.

The Control Valve pressure drop, excluding pressure recovery, shall be 1/3 of all other friction losses in the system at the maximum flow rate, or 15 Psi, whicever is the greater.

Linear Valve shall be sized to pass normal flow at a valve travel of approximately 70% maximum flow shall occure at not greater than 90% of valve travel.

Where the pressure drop across a control valve is less than 30% of the dynamid pressure drop , consideration should be given to other forms of flow control.

Where valves are mounted between pipe reducers, the calculated CV shall be corected by a correction factor.

Where the Reynold number is below 10,000, if necessary, correct the valve capasity for the effect of viscosity.

The cavitation or flashing condition in the control valve shall be determined in accordance with ANSI/ ISA S75.01, Section 8.0. If cavitation cannot be eliminated, then a special valve with anti cavitation trim shall be selected.

The minimum body size shall be 1 inch, except where the line sizes is less than 1 inch, in which case a line sized body may be used. The valve body may have same sizes as the calculated trim, but shall not be smaller than one half of the line size. Where oversized bodies are used, for example, to reduce the outlet velocity, a reduced trim to the standard may be used.

3.4 ACCESSORIES

To satisfy the various valve functionality necessitated by process requirements, such accessories as solenoid valves, lock-up valves, quick-exhaust valves, volume boosters, restrictors, and volume tanks may have to be installed in the valve air circuits. If such accessories are required, they shall be manufacturer's standards unless otherwise specified.

All control valve accessories, with the exception of the air volume tanks, shall be mounted and assembled on the valve actuators by the valve manufacturer.

All control valves shall be provided with an indicating device to show the position of the valve, whether under the action of the control signal or hand wheel. Where control valves and accessories are to be installed in locations susceptible to seismic disturbances, ail components shall be designed to sustain the anticipated stresses and to function normally after the disturbances have passed.

3.4.1 Valve Positioners

- Control valve positioners shall normaly be fitted to control valves on modulating services, unless a system analysis clearly indicate that a positioner is not required. The positioners shall normaly be suitable for input signals of 3-15 psi or 4-20 mA. The use of valve positioners accepting digital input signals, e.g. Hart or fieldbus, shall require the approved of the Contractor/ Company.
- Control valves positioner shall be direct acting.
- The positioner loop gain shall be between 50 & 100.
- Where the positioner control signal input is pneumatic and of the same range as the valve input signal a positioner by pass may be included to allow servicing of the positioner without taking the valve out of services.
- Control Valve positioners shall include gauge indicating the supply and output air pressures. Pneumatic positioners shall include an additional gauge indicating the control air signal.
- Electronic control valve positioner, if approved by the Contractor/ Company, shall be certified for use in accordance with the area classification.
- Power Supply : 24 VDC

- The positioner casing shall give protection to IP65 in accordance with IEC 60529.
- Electro-pneumatic I/P valve positioners shall be used and the output shall be direct acting, unless otherwise specified. Smart type based on HART protocol I/P positioners may be applied, when it will contribute from the total plant minimum cost points of view.
- A combination of an electro-pneumatic converter and a pneumatic valve positioner may be considered at locations where excessive vibration is expected, etc.

3.4.2 Hand wheels

A facility for manual operation will be specified on the data sheets (if required) for all the control valves that do not have block and by pass valves. Hand wheels shall be shown on P&ID's.

Side-mounted, lockable, screw or gear drive manual operators, continuously connected and operable through an integral declutching mechanism are preferred.

Hand wheel should be permanently marked to indicate valve open and closed directions.

Control valves Vendor shall indicate the maximum human/operator force at the rim of the hand wheel in their specification.

The handwheel shall generally be of non-declutchable type.

Re –orientation of the handwheel should be possible with the valve in-situ and without the use of addtional components.

3.4.3 Limit Switches

Limit switches are used wherever remote valve position indicates are required, and shall be fitted according to P&ID requirements.

Limit switches shall have the following characteristics:

- Anti corrosion hermetically sealed fully proven construction
- Contact rating: 24 VDC -1 A
- 2 x SPDT contact with gold plated contact
- Enclosure shall be suitable for hazardous area classification in which they will be installed.
- Mounting : bolt & nuts shall be stainless steel
- Connection : ½" NPT
- Tag No Plate
- Material of construction shall be manufacturer's standard suitable for coastal corrosive atmosphere.
- Electrical components shall be pre-wired to terminal box

3.4.4 Air Filter Regulators

Adjustable air filter regulators will be required when the operating pressure of the actuators or accessories is lower than the maximum air supply pressure. If the actuators and accessories are capable of withstanding the specified maximum instrument air supply pressure, any regulator may not be supplied, but it shall not be affected by fluctuation of supply air header pressure.

3.4.5 Instrument Air Tubing

Instrument air tubing shall be made of 316 SS with 316 SS fittings. Air connections shall be NPT standard as a rule. Must standart ASTM A-264.

3.4.6 Position Indication

Local stem position indicator shall be provided for all valves to show the degree of valve opening.

Rotary type valves, i.e. butterfly and ball valves, shall have a saw cut or other permanent indication on the exposed shaft to identify disc open/close location.

3.4.7 Lock-up Devices

Air lock-up devices shall be provided as specified in the data sheets for all services requiring that the valve remains in the position in which it was immediately before the air failure. On valves with a positioner, the lock-up valve shall be installed between the positioner output and the actuator. Where lock-up valves are applied on valves operated by a solenoid valve, this solenoid valve shall be installed between the lock-up valve and the actuator.

3.4.8 Limit Stops

- Limit stops, which prevent the valve fully opening or closing, shall be provided only when indicated in Data sheets.
- Limit stops shall be mechanical devices mounted on the actuator, they shall not form part of the handwheel mechanism. Pneumatic limit

stops may only be applied only be applied with the approval of the Contractor/ Company.

- Limit stops shall be adjustable over the specified range and be fitted with a temper proof locking facility.

3.4.9 Volume Boosters

- Volume boosters shall be used where it is required that a valve achieve a short stroking time in both directions.
- Volume boosters for pneumatic actuators shall be of the high capasity type with fash throttling facilities to control the required capasity.
- Volume boosters shall be installed on the actuator.

3.5 PAINTING

All control valves required to "fail locked" shall be painted silver, "fail open" shall be painted green and those required to "fail close" shall be painted red.

Valve bodies shall be painted two coats of standard Vendor paint suitable for salt laden atmosphere. Vendor to advice purchaser which paint he is using.

4.0 OVERVOLTAGE (SURGE) PROTECTION

Protection from power and spikes caused by lightning and other sources shall be installed to protect all electronic circuits. These circuits include, but are not limited to field devices such as positioners. The protection devices shall be located as near as possible to the terminals of the equipment to be protected and installed in accordance with the manufacturer's instructions. Attention must be given to grounding the circuits adequately.

5.0 RFI IMMUNITY

All electronic equipments which uses an electronic analog or digital signal internally or as an input or output device, must be certified from the manufacturer that the device isn't susceptible to radio frequency interference.

These devices must operate satisfactorily when subjected to the following Radio Frequency noise environments, these are:

- 20 volts / meter below 14 KHz.
- 10 volts / meter at 14 KHz to 30 MHz.
- 5 volts / meter above 3 0 MHz to 10 GHz.

Acceptable RFI immunity is required when the equipment is being used in its normal operational configuration or a configuration used for calibration and checkout.

6.0 TROPIC PROOFING

Generally Vendor's standards method of Tropic Proofing shall be applied for individual control valve with the following minimum requirements:

a. Proper design and construction.
b. Selection of materials not susceptible materials to fungus growth or moisture.
c. Treatment of any susceptible materials with a protective coating to prevent the growth of fungus. To prevent corrosion and to prevent absorption of moisture.

In addition to above, data sheets for individual control valve shall be referred for further details.

7.0 NAMEPLATES

All nameplates for the control valves shall be in accordance with the "General Instrument Specification", Document No. PSFT-WK-SP-60-001-A4. In addition to above, the following will be required. An identification nameplate shall be provided on each control valve furnished. Nameplate shall be permanently attached using 316 SS bolts and nuts. Adhesives shall not be used.

Nameplates for control valves shall be 316 SS plate, mounted on the operator yoke assembly for visibility. Stainless steel dymotape shall not be used for nameplate. The thickness of the stainless steel nameplate shall be over 2mm.

Letter size shall be 3/16" minimum height. Letter shall be engraved. Printing or painting the letter on the stainless steel plate is not accepted. The following information shall be shown on the nameplate:

a. Valve Serial Number
b. Valve & Instrument Tag Number
c. Valve Model Number or Catalog Number, where applicable
d. Bench calibration of operator stroking range in psig
e. Upstream design pressure
f. Maximum pressure in psig
g. Maximum capacity index (Cv) of the valve
h. Port size or inner valve size, if different from port size.
i. Trim material
j. Body material
k. Plug type
l. Valve stroke (stem travel in inches)
m. Action, air to open or air to close

8.0 INSPECTION, TESTING, COMMISIONING & APPROVALS

INSPECTION

a. Procedures

- The inspection requirement shall form part of the Purchase/ Contract. Additional requirement are given below.
- The Tenderer shall allow the inspector free access to all areas of manufacture, fabrication, assembly and testing.
- The Tenderer always has the responsibilty to provide adequate quality control and inspection of equipment and materials. Any inspection by the contractor/ company shall not relieve the Tenderer of these responsibilities or those under his warranty.
- The face to face dimensions of flanged valves shall be checked for conformance to ANSI/ ISA S75.03. Other dimensions, including overall height, shall be checked against the Tender's approved drawings. The flange face finish shall be checked by visual and tactile comparison again test specimens conforming to the required specification.

NAME PLATES

A corrosion –resitant identification plate shall be fixed by means of rivets or screws to the valves. The plate shall as minimum, carry the following information:

- Manufacturer's name or trade mark.
- Valve and actuator model/ type number.
- Body rating.
- Size of body and trim
- Material of the parts exposed to the process fluid.
- Trim characteristics

- Actual CV Valve
- Spring range
- Action on air supply and/ or signal failure
- Actuator size
- Stem packing materials

  A stainless steel tag number shall be attached to the valve by a stainless steel wire.

MARKING

The direction of flow and where applicable the tight shut-off direction shall be cast or stamped on the valve body. The body shall be marked with the relevant material standard.

TESTING

Statutory Test

Control valves shall be subjected to the factory tests detailed in this section. The Contractor/ Company owner may at his discreation, witness all or part of the factory tests. The test results shall in any case be made available to the Contractor/ Company owner.

Inspection shall be required on all aspects of the Vendor's documentation in relation to any "as built" drawings, applicable certification and test material certificates. Vendor shall submit the test and inspection procedure to Company/Contractor for approval.

Individual calibration testing of control valves will be required as well as pressure testing, NDT, leak testing as stated in the particular specifications and

data sheets. Following test and inspection shall be included to the control valves, as the minimum:

Pressure Test

Valve Hydrostatic Pressure Test shall be conducted according to Vendor standard. Provided Diaphragm case external leakage pressure test shall be also conducted.

Seat Leakage Test

Regarding the seat leakage test class of control valves, ANSI/FCI 70-2: Control Valve Seat Leakage shall be applied. The seat leakage test shall be executed accordingly by the valve manufacturer and witnessed by the Company/Contractor.

NDE Tests

Requirements of NDE test and alloy verification for control valves shall be subjected to their requirements for piping valves. Piping specification shall be referred.

9.0 QA/QC CERTIFICATION

Vendor shall provide the QA/QC Test and Inspection Certificates / Reports for the complete supply :

a. QA/QC Certification for visual controls:
   - Type and model,
   - Material
   - Rating

- Scale
- Operating range
- Labeling
- Pamting
- Dimensions (flanges, threading, piping)
- Certificate of conformity for equipment used in hazardous areas

b. QA/QC Certification for Functional Tests:

Control valves manufacturers shall test and calibrate each control valves at factory against the specification and data sheet requirements. Each control valve shall have a calibration certificate which shall include:

- Measure 5 points : 0%, 25%, 50%, 75%, 100% (increase and decrease)
- Threshold set point and dead band (increase and decrease)