

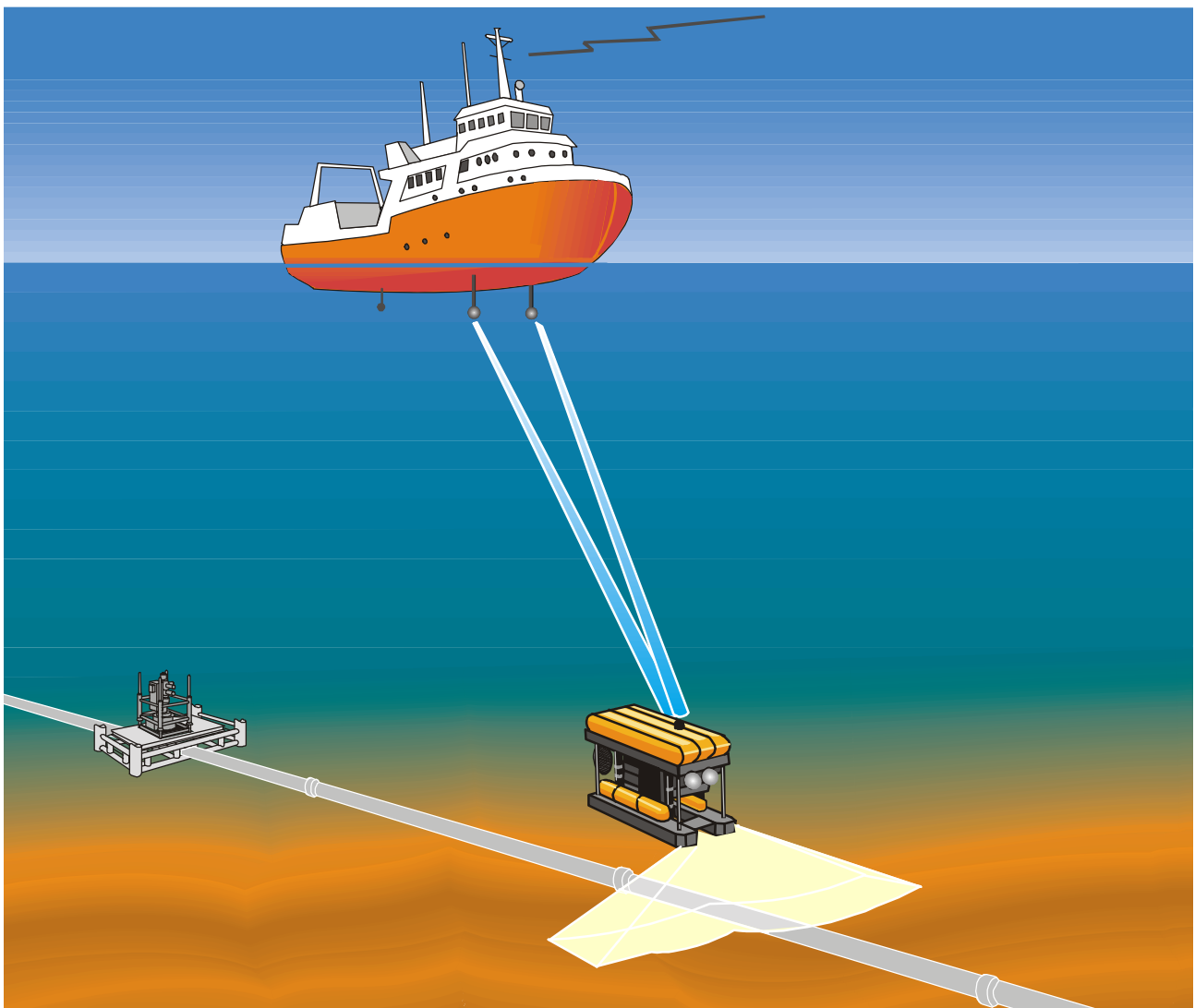


KONGSBERG

Product description

HiPAP system

High Precision Acoustic Positioning system



855-164268

HiPAP system

High Precision Acoustic Positioning system

This document describes the High Precision Acoustic Positioning (HiPAP) system. The HiPAP system is designed for positioning of subsea targets on both shallow and deep water.

The system uses both Super Short Base Line (SSBL) and Long Base Line (LBL) positioning techniques.

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Rev. E	Implemented the HiPAP 450 system, the MPT 341 "Shorty" transponders, and new 19" display. Updated function list. Minor corrections in the text.
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Kongsberg Maritime AS		 KONGSBERG
Strandpromenaden 50		
P.O.Box 111		
N-3191 Horten, Norway		
Telephone: +47 33 02 38 00	Telefax: +47 33 04 44 24	
www.kongsberg.com		
E-mail: subsea@kongsberg.com		

Contents

INTRODUCTION	1
Contents	1
List of abbreviations	1
HiPAP system.....	2
HiPAP 500	2
HiPAP 450	3
HiPAP 350	3
Operating modes	4
APOS.....	4
Sensors.....	4
POSITIONING PRINCIPLES.....	5
Introduction	5
SSBL positioning.....	5
LBL positioning.....	7
Calibration.....	7
Positioning.....	7
Combined SSBL and LBL positioning	9
Multi-User LBL positioning	9
MEASUREMENT COMPENSATION	11
Roll - pitch - heading compensation.....	11
Ray bending compensation.....	12
Transducer alignment	13
APPLICATIONS.....	15
Dynamic Positioning (DP) reference.....	15
Subsea survey and inspection.....	15
Rig and Riser monitoring	15
Acoustic Blow Out Preventer (BOP) control	15
Construction work and metrology	16
LBL Transponder positioning	16
LBL High Accuracy Metrology	16
SYSTEM UNITS	17
General	17
Operator station	17
General	17
Operator Station configuration.....	18
Standard operator station.....	18
Operator console	19
Operator console integrated with SDP XX	19

HiPAP transceiver units	20
General	20
Transceiver function.....	20
HiPAP 500 transducer	21
HiPAP 450 transducer	21
HiPAP 350 transducer	21
HiPAP hull units.....	22
Introduction	22
HiPAP 500	22
HiPAP 450	22
HiPAP 350	22
Hoist Control Unit	23
Remote Control Unit	23
Gate valves	23
Mounting flange	23
EXTERNAL INTERFACES	24
Position outputs	24
Surface navigation	24
Vertical Reference Unit (VRU).....	24
Gyro compass	24
Integrated attitude sensors	25
Interface specification.....	25
SYSTEM CONFIGURATIONS.....	26
General	26
Single HiPAP system	26
Redundant HiPAP system	26
Dual HiPAP 500 system.....	26
Accuracy improvement	27
Redundancy improvement	27
TRANSPONDERS	30
General	30
MPT series.....	31
SPT series	32
MPT 341 “Shorty” series.....	33
MST series.....	34
SYSTEM FUNCTIONS	35
Introduction	35
Main functions.....	35
General	35
List of main functions	35

TECHNICAL SPECIFICATIONS	41
SSBL accuracy	41
HiPAP 500	41
HiPAP 450	44
HiPAP 350	44
LBL accuracy	46
Range capabilities.....	47
Unit specifications	48
APC 10 computer.....	48
Keyboard.....	48
Trackball	49
Display 19” TFT	49
HiPAP transceiver unit.....	49
Heading reference (both models).....	50
Roll and pitch reference (both models).....	50
HiPAP hull units	51
Hoist Control Unit.....	51
Remote Control Unit	52
Flanges	52
Gate valves	53
Outline dimensions	54
APC 10 computer.....	54
Keyboard.....	55
Trackball	55
19” TFT display	55
Operator console	57
HiPAP transceiver unit – outline dimensions	58
HiPAP transceiver unit door w/cooling unit	59
Gate valve and flange – 500 mm.....	60
Gate valve and flange – 350 mm.....	61
Hoist Control Unit.....	62
Remote Control Unit	63
HiPAP hull units.....	64
HiPAP 500	64
HiPAP 450	64
HiPAP 350	64
HiPAP 500 HL 2180	65
HiPAP 500 HL 2180 without dock and gate valve	66
HiPAP 500 HL 3770	67
HiPAP 500 HL 4570	68
HiPAP 500 HL 6120	69
HiPAP 350 HL 2180	70
HiPAP 350 HL 3770	71
HiPAP 350 HL 6120	72

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INTRODUCTION

Contents

This description covers the High Precision Acoustic Positioning (HiPAP) system. It provides a general description of the systems, each module, the functions and technical specifications.

List of abbreviations

ACC	Acoustic Control Commander
ACS	Acoustic Control Subsea
APC	Acoustic Positioning Computer
APOS	Acoustic Positioning Operator Station
BOP	Blow Out Preventer
DGPS	Differential Global Positioning System
DP	Dynamic Positioning
GPS	Global Positioning System
HiPAP	High Precision Acoustic Positioning
LBL	Long Base Line
MST	Mini SSBL Transponder
MPT	Multifunction Positioning Transponder
MULBL	Multi-User Long Base Line
ROV	Remotely Operated Vehicle
SPT	SSBL Positioning Transponder
SSBL	Super Short Base Line
VRU	Vertical Reference Unit

HiPAP system

The HiPAP system is designed to provide accurate positions of subsea targets such as Remotely Operated Vehicles (ROVs), towed bodies or fixed transponders. To achieve the accuracy, the HiPAP system uses a spherical shaped transducer design and a new signal processing technique. This new technique enables narrow beams to be generated in all directions within the lower half of the transducer using only electronic beam control. The HiPAP system operates as an SSBL system, measuring angles and range by using a unique processing technique that provides very high accuracy. For LBL operation the system can simultaneously position several seabed transponders and compute the vessel's position.

The following HiPAP systems are available:

- HiPAP 500
- HiPAP 450
- HiPAP 350

All HiPAP systems have common software and hardware platforms and thereby offer the same kind of additional functionality and options.

HiPAP 500



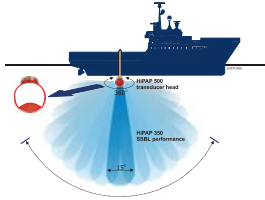
The HiPAP 500 has a full spherical transducer body including 241 transducer elements. This model has close to full accuracy in the half sphere sector and is the preferred system where the best possible performance is required. The HiPAP 500 can also track targets above the half sphere sector.

The use of *very narrow beams* provides:

- High accuracy
- long range
- good noise reduction capabilities.

The HiPAP 500 transducer has a diameter of 392 mm and will be installed with the 500 mm gate valve.

HiPAP 450



The HiPAP 450 system has the same operational and technical performance as the HiPAP 350 system.

→ Refer to *HiPAP 350 system description on page 3.*

The HiPAP 450 transducer is the same unit as the HiPAP 500 transducer, but only the 46 lower sector elements of the sphere are “activated” and in use.

The HiPAP 450 uses the same hull units as the HiPAP 500.

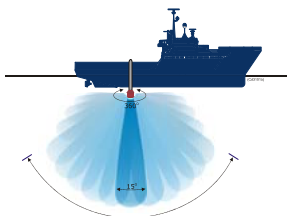
→ Refer to *HiPAP 500 system description on page 2.*

Upgrade to HiPAP 500

The HiPAP 450 can be upgraded to full HiPAP 500 performance. This is done by:

- Installation of 6 additional Transmitter / Receiver Boards in the transceiver unit.
- APOS software upgrade.

HiPAP 350



The HiPAP 350 has a spherical transducer with a cylindrical body including 46 transducer elements. This model has good accuracy in the $\pm 60^\circ$ coverage sector and is suited for operations where the major positioning targets are within this sector.

The use of *narrow beams* provides:

- High accuracy
- long range
- good noise reduction capabilities.

The HiPAP 350 transducer has a diameter of 320 mm and it will be installed with a 350 mm gate valve. Installing the system with a 500 mm gate valve, will enable an easy upgrade to a HiPAP 500 system.

Operating modes

- **SSBL** - Positions various targets by directional and range measurements.
- **LBL** - Positions the surface vessel by simultaneously use of combined directional and range measurements to transponders in an LBL array.
- **MULBL** - Positions the surface vessel in an MULBL transponder array.
- **Telemetry mode** – acoustic communication to:
 - transponders for LBL calibration, metrology measurements and set-up
 - instrument units and BOP systems.

APOS

The HiPAP system is operated from the APOS, which is a Windows XP based software used to operate the HiPAP system. The system can be operated from one single APOS station or from a wide number of APOS operator stations connected on a network.

The APOS software can also be integrated with the Kongsberg DP system.

Sensors

The HiPAP system has a wide range of interfaces to sensors from different manufacturers.

A gyro compass and a vertical reference sensor will normally be interfaced to a HiPAP system.

POSITIONING PRINCIPLES

Introduction

The HiPAP system uses two different principles for positioning; the SSBL and the LBL. These two principles have different properties that make the system flexible for different applications.

- The SSBL principle is based on a range and direction measurement to one transponder, while the LBL principle is based on range measurements to minimum three transponders on the seabed.
- The position accuracy in SSBL is proportional to the slant range to the transponder, while the LBL accuracy is determined by the geometry of the seabed transponders array and the vessel that is being positioned.
- The SSBL principle, due to its simple operation, is the obvious choice if the accuracy is good enough for the application being done. The LBL principle is the obvious choice if the SSBL accuracy is not good enough for the application being done, though it requires a more complex operation.

SSBL positioning

In SSBL, the system calculates a three-dimensional subsea position of a transponder relative to a vessel-mounted transducer. The position calculation is based on range and direction measurements to one transponder. The onboard transducer transmits an interrogation pulse to a subsea transponder, which then answers with a reply pulse. When using a responder the interrogation is replaced by a hard wire trigger connection.

- The onboard system will measure the time from the interrogation to the reply pulse is detected and use the sound velocity to compute the range.
- The transponder position is presented both numerical and graphically on the operator station. Only one onboard SSBL type transducer is necessary to establish this position.

Using a pressure sensor in the subsea transponder can increase position and depth accuracy. The pressure is measured and transmitted to the surface HiPAP system using acoustic telemetry. The depth is then used in the algorithms for establishing the 3D position. The system can also read the depth via a serial line input from a pressure sensor. Simultaneous use of many transponders is made possible by using individual interrogation and reply frequencies.

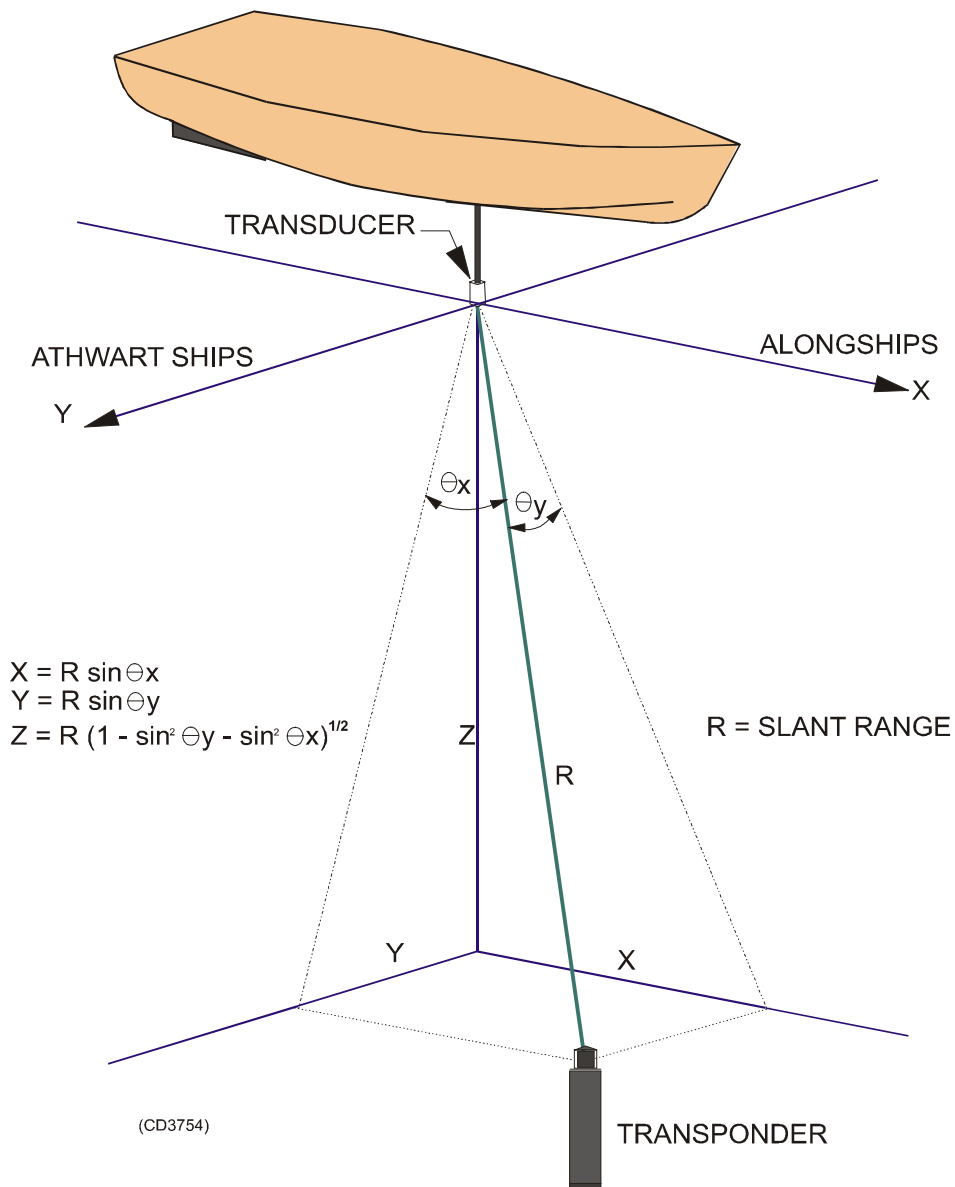


Figure 1 – SSBL principle

LBL positioning

Calibration

The LBL principle is based on one vessel-mounted transducer, and normally 4 - 6 transponders on the seabed. This seabed transponder array must be calibrated before LBL positioning operations can begin. The calibration shall determine the transponder's positions in a local geographical co-ordinate frame. The HiPAP system supports two calibration techniques:

Baseline measurements

This technique uses automatic calibration functions in the HiPAP system. This allows all the ranges to be measured and made available by acoustic telemetry communication between the transponders and the vessel's system. Based on the baseline measurements and initial positions of the transponders, the calibrated transponder positions are computed.

Runtime calibration

To use this technique, the system is run in LBL positioning mode, using the SSBL positions of the seabed transponders for the vessel LBL position calculation. The runtime calibration function logs the measurements. Based on this, new optimised seabed transponder positions will be computed. This technique makes the baseline measurements redundant. If the baseline measurements are done, they are also used in the calculations. The calibration is performed only once prior to positioning operation, since the transponders will remain in the same location during the operation.

Positioning

When the transponder positions are known, positioning of the surface vessel can begin. All the seabed transponders will be interrogated simultaneously, and each will respond with its specific reply signal. The LBL system will then calculate the ranges from the individual transponders. By using the calibration data together with the calculated ranges in software algorithms, the vessel or an ROV can be positioned. ROV positioning requires an HPR 400S transceiver to be mounted on the ROV.

- The system can take the depth from an ROV-mounted pressure sensor via a serial line. By using this depth in the computation, it will increase the position accuracy of the ROV.

- The range capabilities of a medium frequency LBL system will be approximately the same as those of an SSBL system.
- LBL positioning will give better position accuracy at greater water depths, but is more complex to operate, and it needs more transponders than the SSBL.
- LBL TP positioning method uses one transponder to measure the ranges to the transponders in the array and telemetry the data to the surface vessel, which computes the position of the transponder.

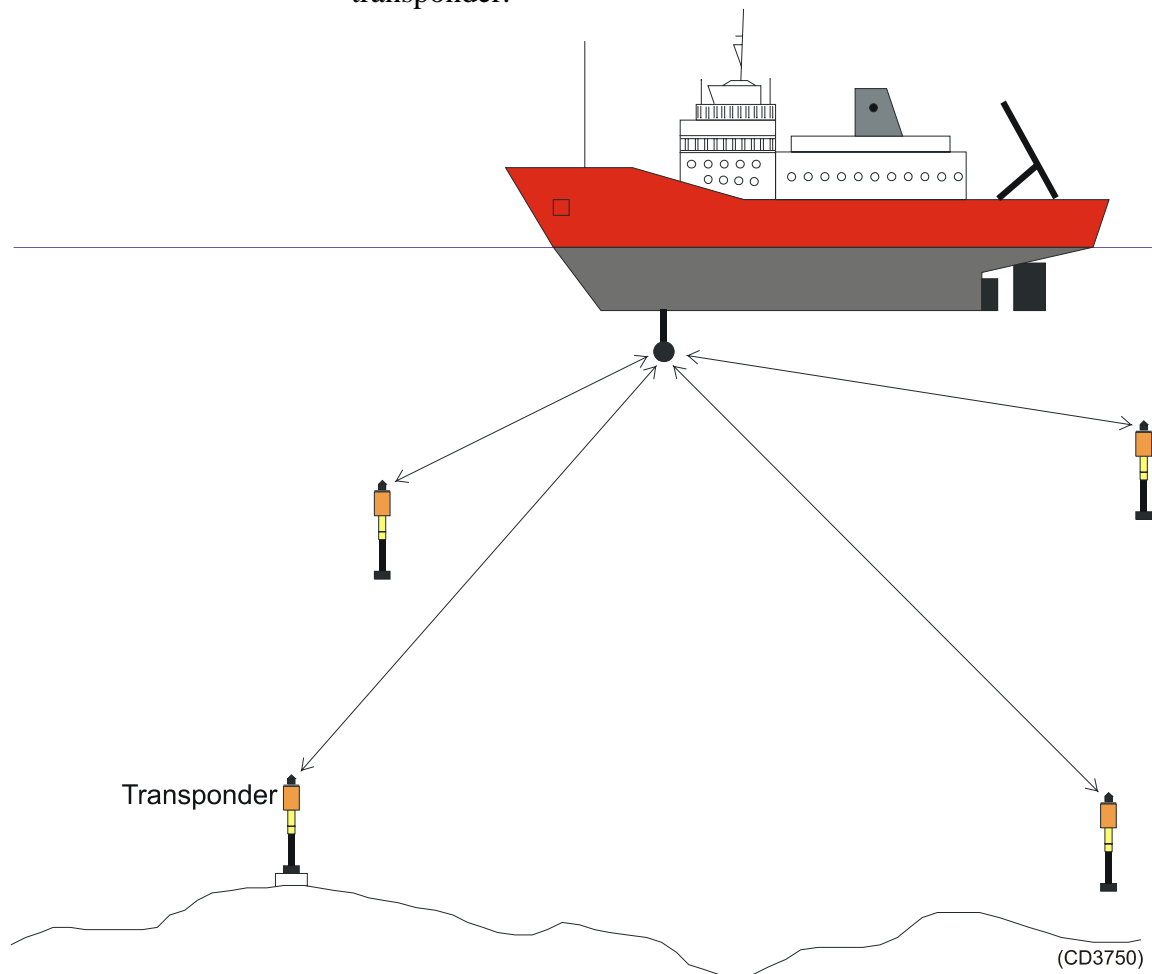


Figure 2 LBL principle

Combined SSBL and LBL positioning

The combined SSBL/LBL system uses an onboard multi-element transducer. The system may operate as an SSBL system and as an LBL system simultaneously.

As an example, the vessel may be positioned relative to the seabed using LBL while an SSBL transponder/responder on an ROV is positioned relative to the vessel. The vessel is displayed relative to the array origin and the ROV relative to the vessel. The combined system will also use the measured directions in 2D together with the measured ranges in the LBL positioning. The combined measurement gives a robust system with increased accuracy. An LBL solution is achievable when only two transponder replies are detected.

Multi-User LBL positioning

Several individual vessels and ROV units can now position themselves using the same seabed transponder array. The system and principle has the following main advantages:

- Provides high position accuracy (comparable to standard LBL).
- A small number of transponders serve all vessels and ROVs.
- Secures high position update rate (down to approx. 2 seconds), which is essential in DP operations.
- Avoids transponder frequency collisions when vessels are working in the same area (all vessels are "listening" only).

A transponder array is deployed and calibrated by use of subsea baseline measurements. One transponder is used as the Master in the positioning phase. The other transponders are called the Slaves.

The Master transponder acts as a beacon. It starts a positioning sequence by doing the steps described below. This is done regularly with an interval set by telemetry from one of the vessels.

- 1 The Master interrogates the Slaves.
- 2 The Master transmits its individual transponder channel to be received by the vessels/ROVs positioning in the array.
- 3 Each Slave transponder receives the interrogation from the Master and transmits its individual reply channels after a turnaround delay.

A MULBL system positioning in the array listens for the individual channels transmitted by the master beacon, and by the Slave transponders. When they are received, the system uses its knowledge about their positions in the TP array to calculate the differences in range to the transponders in the TP array. The time difference between the Master interrogation and the start of the reception of the pulses at the system is unknown. It has to be calculated together with the position of the vessel or ROV. All vessels to use the MULBL array need the coordinates of the transponders and the channel numbers, which will be distributed of a file.

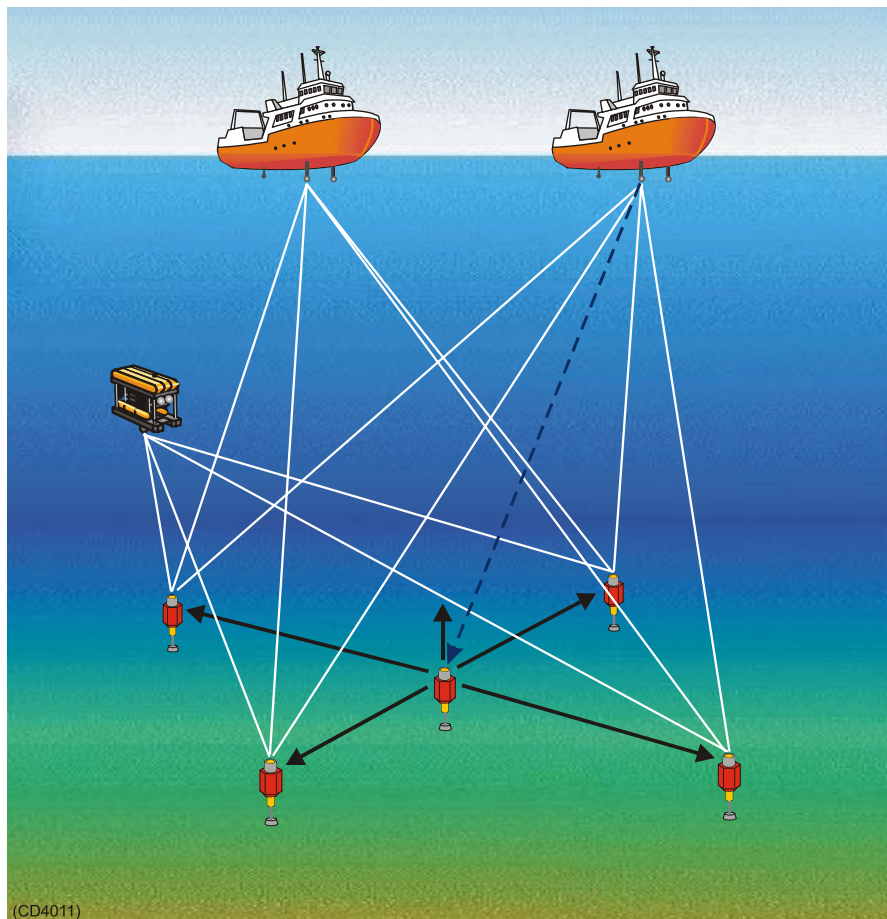


Figure 3 Multi-User LBL positioning

MEASUREMENT COMPENSATION

Roll - pitch - heading compensation

In order to compensate for the vessels roll / pitch / heading movements, vertical reference sensors and heading sensors are interfaced. Data from these sensors are used to compute position data that is relative to horizontal level and to north.

The absolute accuracy and the standard deviation of the position are very dependent of the roll / pitch / heading sensors performance. Especially when working at great waterdepths the roll / pitch / heading error contribution is significant and when working at long horizontal range the heading error contribution is significant. This compensation is used in all positioning modes.

The accuracy of the attitude data is of crucial significance for the total accuracy of the HiPAP system, and the error from the attitude sensor will add to the error of the HiPAP system.

Example:

A roll or pitch error of 0.25 degrees will give an error of 4.4 m at 1000 m depth, and an error of 13 m at 3000 m depth - while a roll or pitch error of 0.05 degree will give respectively 0.9 m and 2.6 m.

Ray bending compensation

Positions calculated from the raw measurements are influenced by variable sound velocity through the water column. The variable sound velocity causes an error in both range measurements and the angular measurements. By use of a sound profile, the system can correct these errors.

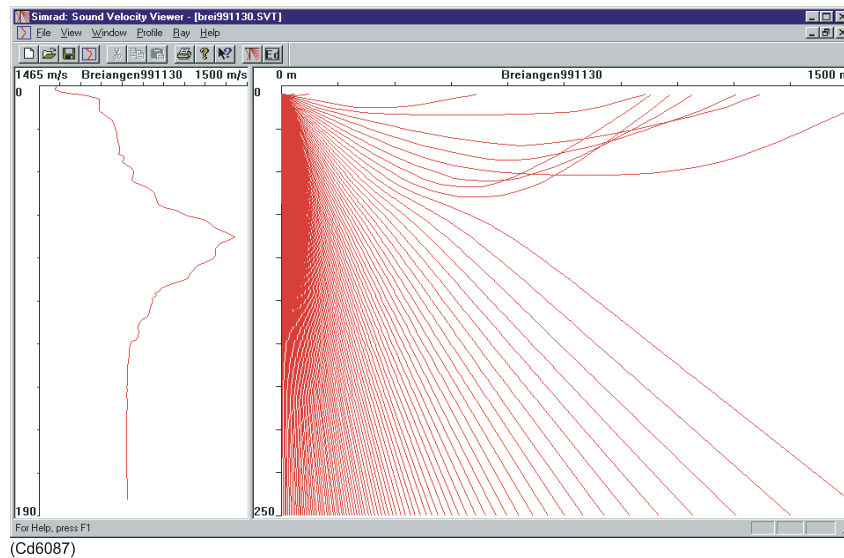


Figure 4 Sound profile - APOS presentation

The sound velocity values may be measured by a probe and transferred to the system. If the depth of the target (transponder) is known either by depth sensor in the transponder or by an ROV depth sensor, these data can be transferred to the system and they will be used in the compensation.

The range calculation is compensated for the error caused by different sound velocities in the water column, and for the extra propagation path caused by the ray bending. The angular measurements are compensated for the ray bending.

The compensation is used in all positioning modes.

Transducer alignment

After a HiPAP installation, it is necessary to determine a number of offsets between various sensor reference points and axes.

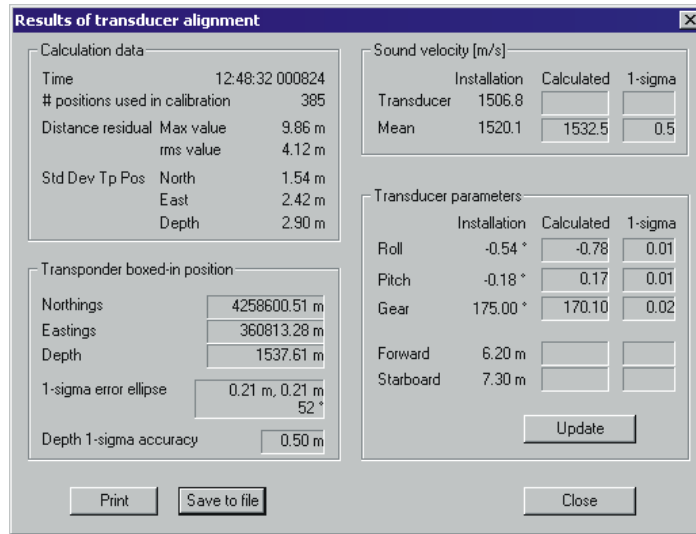
These are:

- Vertical angular - The offset between transducer axis and roll / pitch sensor axis.
- Horizontal angular - The offset between roll / pitch sensor and heading reference.
- Horizontal angular - The offset between transducer axis and heading reference.
- Horizontal distance - The offset between transducer location and reference point.

The principles for these alignment adjustments are based on the position of a fixed seabed transponder relative to the vessel and the geographical position of the vessel.

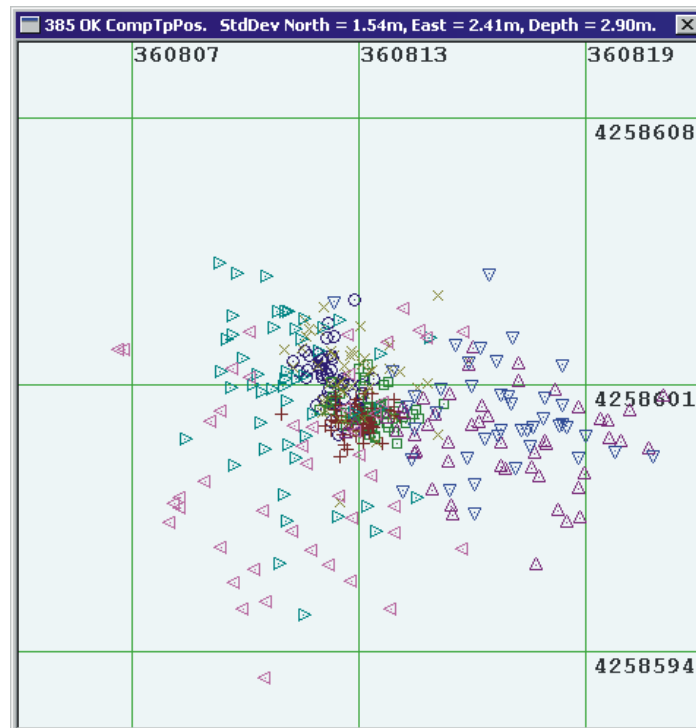
In order to simplify and improve the quality of the alignment scenario, the alignment function in APOS is used. By logging the vessel position from DGPS along with the measured HiPAP position of a seabed transponder, the program computes the alignment parameters. The normal procedure is to locate the vessel at four cardinal points and on top of the transponder with four headings.

Immediately the alignment parameters can be computed and automatically be transferred to the APOS alignment parameters. No manual transfer is needed. The results from the alignment are shown both numerical and graphically on the APOS. An example is shown in the two figures below.



(Cd5886)

Figure 5 Result of transducer alignment - APOS presentation



(Cd5885)

Figure 6 Transponder positioning - APOS presentation

The figure shows the positions at the seabed transponder in UTM co-ordinates after the compensation values are determined and applied. The various symbols are used so readings from different locations easy can be separated from each other.

APPLICATIONS

Dynamic Positioning (DP) reference

The position data can be used by a DP system as the reference signals for keeping the vessel in the desired position. High position accuracy and reliability ensure a secure and stable reference input to the DP systems. SSBL and LBL systems may be used.

Subsea survey and inspection

Positioning of ROVs carrying instruments for survey and inspection is another important application for the HiPAP system. The ROV position relative to the vessel is integrated with the position from surface navigation to provide a geographical position of the ROV. In this application, a responder is suitable.

Tracking towed bodies for similar applications may also be done. In survey applications, a best possible geographic position is wanted. To obtain this, sound velocity and depth (pressure) sensor input to the HiPAP system may be used.

Rig and Riser monitoring

The HiPAP system can be used to monitor the drill rig position relative to the well/Blow Out Preventer (BOP). It can also be used with inclinometer transponders to monitor the BOP and riser inclination. For HSC 400, interface to electrical riser angle measurement is available. Used with the Acoustic Control Subsea (ACS 400) it can be used for BOP.

Acoustic Blow Out Preventer (BOP) control

The HiPAP system is also used for transmitting and receiving acoustic telemetry command with high security. This is used for acoustic BOP control, which includes BOP valve operation and monitoring critical functions by reading subsea status information and sending this information to the operator onboard the vessel.

A separate unit, the ACS 400, is required on the BOP stack. The ACS 400 contains electronics and batteries for interfacing the BOP.

A portable control unit, the Acoustic Control Commander (ACC 400), is also available. The ACC 400 contains electronics and batteries for operating the BOP functions.

Construction work and metrology

LBL Transponder positioning

A feature in the HiPAP system is to position one transponder relative to an LBL array. One Multifunction Positioning Transponder (MPT) is used to measure the range to other MPTs in an LBL array, and to transmit the ranges via telemetry to the surface HiPAP system. The HiPAP system computes the position of the transponder in the array.

The transponders may be interrogated simultaneously or in sequence. The ranges can be transmitted automatically after the measurement or on a controlled sequence from the surface HiPAP system.

The operator can control the speed of the telemetry link. A position update rate of 4 seconds is achievable. This function is ideal in applications like subsea construction and other object positioning where high accuracy is required and where there is no possibility to have an umbilical.

LBL High Accuracy Metrology

The MPT transponders have a High Accuracy mode that has a very good range accuracy performance. It is possible to measure baselines with accuracy better than 0.05 m. The MPT's are standard units that are operated by the HiPAP system.

The high accuracy and range capabilities obtained using MPTs in medium frequency mode reduces the need for high frequency transponders. High frequency transponders often need additional equipment to be installed onboard.

SYSTEM UNITS

General

A HiPAP system consists of four main units:

- Operator station
- Transceiver unit
- Hull unit with transducer and hoist control
- Gate valve and mounting flange

Each transducer requires a dedicated hull unit arrangement and transceiver unit. One operator station can control several transceiver units.

→ *The units are shown in the system diagrams on page 28 and 29.*

Operator station

General

The Operator station comprises (same for all HiPAP systems):

- APC 10 computer
- Keyboard
- Trackball
- Colour monitor

The computer runs on the Microsoft Windows XP operating system. The user interface is a graphical user interface, designed as a standard Windows XP application.

A Keyboard and trackball, controls the operation.

The screen is divided into 3 windows in which the operator can select several different views. Typical views are graphical position plot, numerical data, inclination and roll, pitch and heading. A normal display configuration is shown in the following figure.

One system may have one or several operator stations, which communicates on an Ethernet. One of the operator stations will be the Master. This is selected by the operator(s).

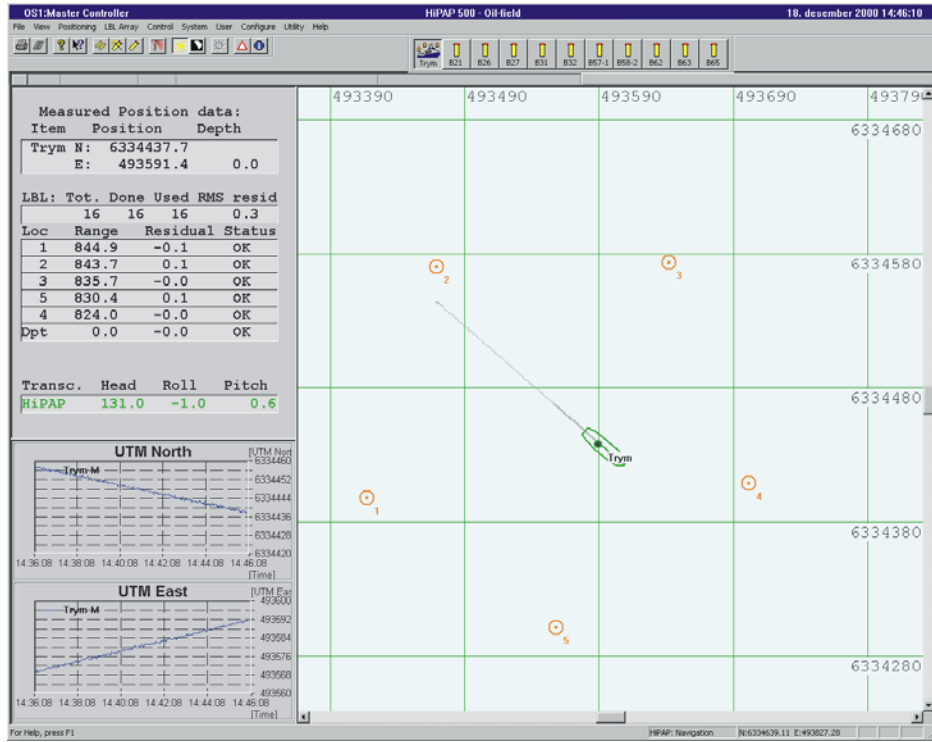


Figure 7 APOS presentation

Operator Station configuration

A HiPAP system may be configured with the Operator Station in two ways:

- Stand alone APC 10 computer, monitor, keyboard and trackball.
- Operator console, integrated with the Dynamic Positioning (SDP).

Standard operator station

APC 10 - Acoustic Positioning Computer

The *APC 10* is the computer in the HiPAP Operator Station. It holds all the operational software and interfaces to display, keyboard, printers, network and other peripheral devices as required. The unit is normally fitted with a 3.5" floppy drive and a CD-read / write unit.

The APC 10 may be mounted desktop attached to the colour monitor, or in a 19" rack.

Display

The colour display, the flat-screen 19" TFT is a general purpose, is a micro-processor based and digitally controlled display unit. The display can be installed in several ways; desktop, roof, panel or 19" rack.

Keyboard

The keyboard is a PS/2 keyboard. It has US layout and includes back-lighting. The keyboard can be mounted on the APC 10 or be placed on a desktop.

Trackball

The trackball is designed for easy use.

Operator console

The stand alone operator console integrates a 21" monitor, the system controller and a keyboard. The console is identical to consoles used with the Kongsberg DP systems. The console is to be mounted on the deck and normally in line with the DP consoles.

Operator console integrated with SDP XX

The integrated HiPAP and DP operation is available as two different solutions.

HiPAP and DP - multiple integrated operator stations

When several operator stations are available, the operator can select to view and operate the DP and the HiPAP on any station. The operation is the same as for a single operator console.

HiPAP and DP - multiple operator stations

When several operator stations are available, it is also possible to dedicate one of the SDP consoles for the HiPAP operator station, and in addition, use other consoles as integrated operator stations for both DP and HiPAP use.

The operation is the same as for a single operator console.

HiPAP transceiver units

General

Two types of HiPAP transceiver units are available:

- 1 HiPAP 500 Transceiver Unit
 - also used for the HiPAP 450 system

- 2 HiPAP 350 Transceiver Unit

The two transceiver units are in principle the same. A HiPAP transceiver unit is interfaced to the spherical transducer array. The transceiver contains transmission amplifiers, A/D conversion circuits and a signal-processing computer. It is interfaced to one HiPAP transducer, attitude sensor(s), and controls the triggering of up to 4 responders. The transceiver outputs the transponder position to the APC 10. The unit is designed for bulkhead mounting close to the hull unit.

Transceiver function

- **HiPAP SSBL processing**
 - The HiPAP system determines the position of a subsea target (transponder or responder) by controlling a narrow reception beam towards its location. The system uses a digital beam-former, which takes its input from all the transducer elements.
 - The system uses a number of wide fixed beams to generate an approximate position for the target. Once this is achieved, it uses data from all the elements on the hemisphere facing the target to compute the narrow reception beam and optimise the directional measurement.
 - The range is measured by noting the time delay between interrogation and reception. The system will control the beam dynamically so it is always pointing towards the target. The target may be moving, and the vessel itself is affected by pitch, roll and yaw. Data from a roll/pitch sensor is used to stabilise the beam for roll and pitch, while directional data from a compass is input to the tracking algorithm to direct the beam in the correct horizontal direction.
 - The HiPAP transceiver can operate with up to 56 transponders simultaneously. The data is sent to the APC 10.

- **HiPAP LBL processing**
 - This mode is similar to the HiPAP SSBL processing, but the transceiver positions up to 8 LBL transponders for each single LBL interrogation. Both ranges and directions to the transponders are measured.
- **HiPAP MULBL processing**
 - This mode is similar to the HiPAP LBL processing, but the transceiver does not interrogate the MULBL transponder array, it only listen for the replies from the array. The transceiver can listen for to 8 LBL transponders. The direction to the transponders and the time difference between the received replies is transmitted to the APC 10.
- **HiPAP Telemetry processing**
 - The unit transmits acoustic telemetry messages, and receives and decodes the acoustic telemetry message from the transponder. The data is sent to the APC 10.

HiPAP 500 transducer

The HiPAP 500 model has a full spherical transducer body including 241 transducer elements, the elements covers its entire surface area except for a small cone around the "north-pole". The large number of elements enables narrow receiver beams to be generated. The transducer is mounted on the hull unit.

HiPAP 450 transducer

The HiPAP 450 transducer is the same unit as the HiPAP 500 but only the 46 lower sector elements of the sphere are "activated" and in use.

HiPAP 350 transducer

The HiPAP 350 has a spherical transducer with a cylindrical body including 46 transducer elements, the elements covers its' +/- 60° cone pointing downwards. The large number of elements enables narrow receiver beams to be generated. The transducer is mounted on the hull unit.

HiPAP hull units

Introduction

The hull unit enables the transducer to be lowered, under either local or remote control, through the vessel's hull to a depth sufficient to minimise the effects of noise and air layers below the vessel. The hull unit is installed on top of a gate valve, which can be closed during maintenance (cleaning) of the transducer. The hull unit also holds the guide-rail arrangement for keeping the transducer exactly aligned with the vessels reference line. The following HiPAP hull units are available:

HiPAP 500

HL 3770 with HiPAP 500 transducer for 500 mm gate valve

This is the normally supplied hull unit for the HiPAP 500. It is supplied with a 500 mm transducer dock to fit on a 500 mm gate valve.

HL 2180 with HiPAP 500 transducer

This HiPAP 500 hull unit has reduced length. It is supplied with 500 mm transducer dock to fit on a 500 mm gate valve.

HL 2180 HiPAP 500 transducer without transducer dock

This HiPAP 500 hull unit has reduced length and is designed in stainless steel for low magnetic permeability. This unit is without transducer dock. The foundation is shipyard supply.

HL 4570 HiPAP 500 transducer for 500 mm gate valve

This hull unit has extended length for HiPAP 500. It is supplied with 500 mm transducer dock to fit on a 500 mm gate valve.

HL 6120 with HiPAP 500 transducer for 500 mm gate valve

This hull unit has extended length for HiPAP 500. It is supplied with 500 mm transducer dock to fit on a 500 mm gate valve.

HiPAP 450

The same as the HiPAP 500 hull units are used.

→ *Refer to HiPAP 500 hull units description.*

HiPAP 350

HL 3770 with HiPAP 350 transducer for 350 mm gate valve

This is the normally supplied hull unit for the HiPAP 350. It is supplied with a 350 mm transducer dock to fit on a 350 mm gate valve.

HL 3770 with HiPAP 350 transducer for 500 mm gate valve

This is a hull unit for HiPAP 350. It is supplied with a 500 mm transducer dock to fit on a 500 mm gate valve.

HL 2180 with HiPAP 350 transducer for 350 mm gate valve

This hull unit has reduced length for HiPAP 350. It is supplied with a 350 mm transducer dock to fit on a 350 mm gate valve.

HL 2180 with HiPAP 350 transducer for 500 mm gate valve

This hull unit has reduced length for HiPAP 350. It is supplied with a 500 mm transducer dock to fit on a 500 mm gate valve.

HL 6120 with HiPAP 350 transducer for 350 mm gate valve

This hull unit has extended length for HiPAP 350. It is supplied with a 350 mm transducer dock to fit on a 350 mm gate valve.

HL 6120 with HiPAP 350 transducer for 500 mm gate valve

This hull unit has extended length for HiPAP 350. It is supplied with a 500 mm transducer dock to fit on a 500 mm gate valve.

A HiPAP hull unit is equipped with the following sub-units:

Hoist Control Unit

This unit holds the power supplies and control logic for the hoist and lower operation of the hull unit. It also has a local control panel for local control of the hoist / lower operation.

Remote Control Unit

This unit is normally mounted close to the display unit in the operation room. It allows remote control of the hoist and lower operation of the hull unit.

Gate valves

There are two different gate valves available, one with 500 mm aperture and one with 350 mm aperture. The valve is hand-wheel operated, delivered with electrical interlock for prevention of lowering the transducer into the gate.

As an option the gate valve can be delivered with an electrical actuator (electrical gate valve operation).

Mounting flange

There are two different flanges available one with 500 mm aperture and one with 350 mm aperture. Standard height is 600 mm. Optional length is available on request.

EXTERNAL INTERFACES

Position outputs

The HiPAP system can be interfaced to other computers allowing them to process the position data for various applications. The system is flexible in the way it interfaces other computers. Several binary and ASCII formats are available on serial line and Ethernet using UDP protocol.

A dual Ethernet is available for secure DP operations.

An accurate time-tagged position output is available if the system is interfaced to a DGPS and synchronised to 1PPS.

→ *Refer to the NMEA 0183 sentences description, doc no. 850-160045.*

Surface navigation

The HiPAP system can be interfaced to a surface navigation system. As standard the system uses DGPS. When DGPS is interfaced, a number of features will become available; UTM grid on display, UTM position of transponders, transducer alignment and geographical calibration of LBL arrays.

Vertical Reference Unit (VRU)

The Vertical Reference Unit (VRU) is interfaced to the HiPAP system transceiver unit. The system can thereby automatically compensate for the vessel's roll and pitch movements. The HiPAP system can use the same VRU as the Dynamic Positioning (DP) system (if one is fitted).

The VRU may or may not be a part of the Kongsberg Maritime delivery. In any case, the unit is documented separately by the applicable manufacturer.

Gyro compass

The gyro compass supplies the HiPAP system with the vessel's heading relative to north. The HiPAP system may then provide transponder coordinates relative to north. It is also used to update the position filter as the vessel changes heading.

Integrated attitude sensors

These sensors integrate rate gyros, accelerometer and GPS to provide an accurate roll, pitch, heave and heading output. These sensors are superior to traditional gyros and VRUs. The HiPAP system may be interfaced to such sensors.

Interface specification

The HiPAP system has several interface formats available. These are described in the *Attitude formats description* document.

→ *Refer to the Attitude formats description, doc no. 853-201392.*

SYSTEM CONFIGURATIONS

General

A HiPAP system may be configured in several different ways, from a single system to a redundant system with several operator stations. Some configurations are described below. These are shown with both a HiPAP 500 transducer and a HiPAP 350 transducer, indicating that the two systems are configured in the same way.

Single HiPAP system

The single HiPAP system has one transceiver and hull unit, but it may have one or more operator stations.

→ *See the system diagram on page 28.*

Redundant HiPAP system

The redundant HiPAP system has two or more operator stations and two or more transceivers and hull units. All transceivers are accessible from all operator stations. The redundant system will operate with 2 transponders, one on each transducer. The redundant system shall still be operational after one single failure in the system.

→ *See the system diagram on page 29.*

Dual HiPAP 500 system

A dual system applies for the HiPAP 500 only. HiPAP is designed to operate two sets of transceivers / transducers, both operated from the same operator station(s).

→ *See the system diagram on page 29.*

The dual system uses both transducers to measure the position of one single target (transponder / responder) by controlling beam forming and directional measurement separately for each system in parallel. This means that both systems will measure and calculate a position for the same reply pulse from the transponder.

If the signal is lost on one of the transducers, it may still be possible to receive it on the other one.

A position estimator will use the position information from both systems to estimate one optimal transponder position. Each system calculates a variance for its measurements, determined from the known system accuracy and the standard deviation of the measurements. The position estimator receives the position and the variance from the two systems, and calculates the weighted mean of the two positions. The variances are used as the weights.

The quality control function uses variance data, standard deviation and position difference to perform a quality control of the position. If the variance and the position difference are outside a pre-set limit, a warning will be displayed for the operator.

For the dual configuration, a synchronisation line between the transceivers is required.

The following paragraphs indicate the benefits of a dual system:

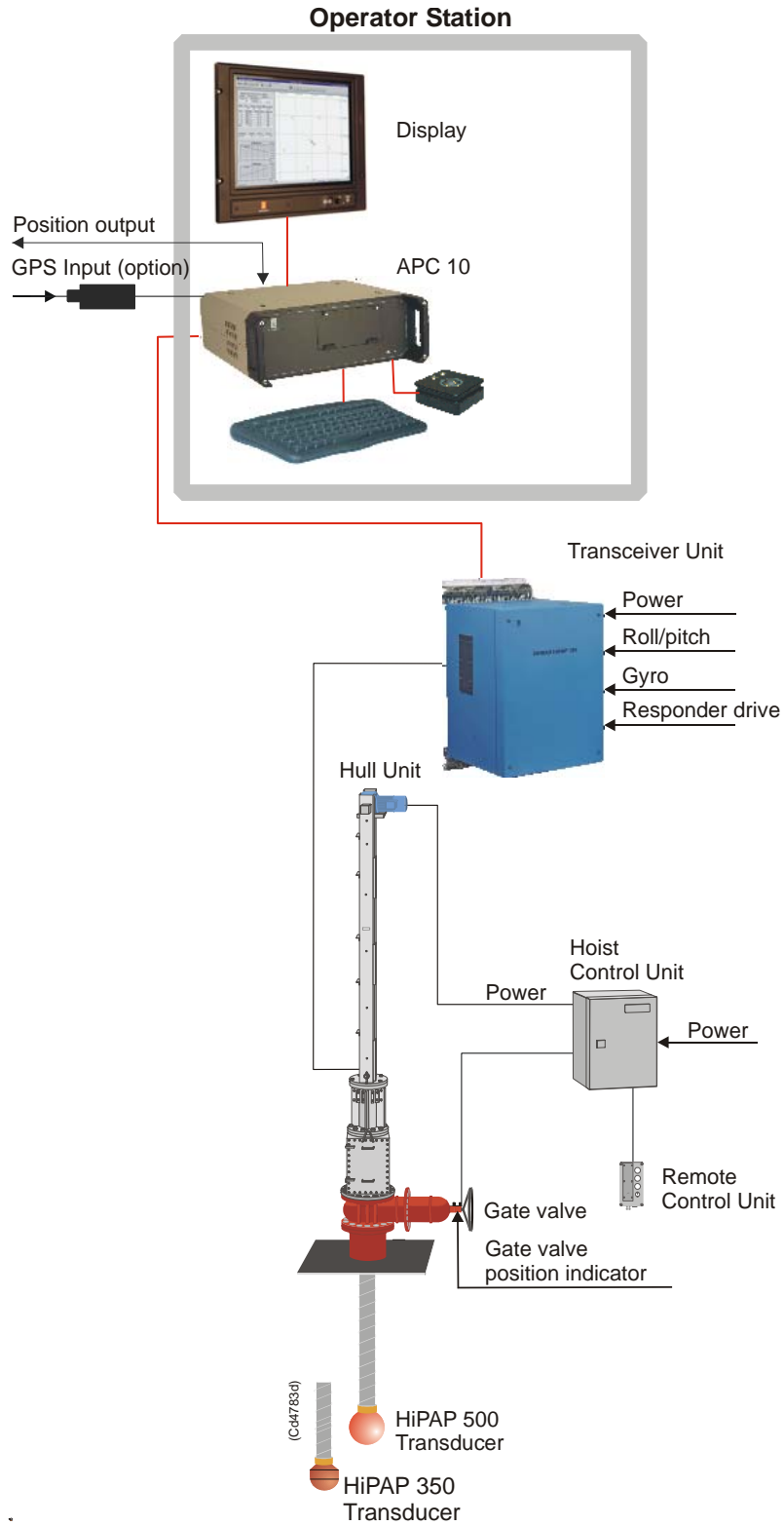
Accuracy improvement

The improvement factor from 1 to 2 transducers is $\sqrt{2}$. This is based on the statistical improvements when using two independent systems.

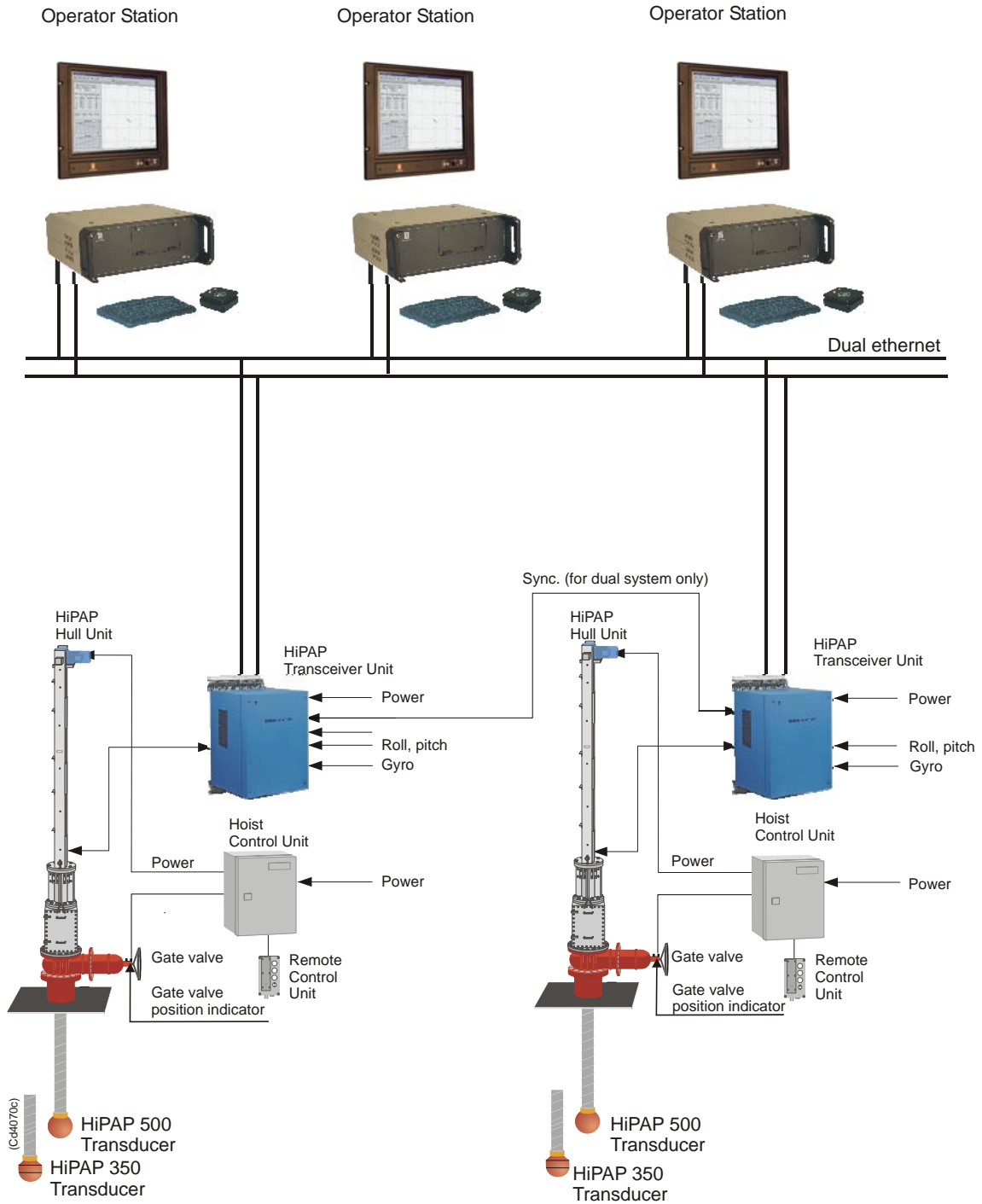
Redundancy improvement

The two transducers will normally be installed at different locations onboard. One transducer may then have a better location with respect to noise environments and reflections than the other. The computed position will be a weighted mean of these two measurements, if one of the systems fails to receive a reply, the other system may still receive it and the position will still be computed.

Single HiPAP - system diagram



Redundant and Dual HiPAP - system diagram



TRANSPONDERS

General

The position calculation is based on range and/or direction measurements from the onboard transducer to the subsea transponder(s). For the HiPAP system, there is a wide range of transponders available. The various transponders models have different depth rating, source level, lifetime, beam pattern and function. The transponder models consist of three series:

- MPT - Multifunction Positioning Transponders
- SPT - SSBL Positioning Transponders
- MPT “Shorty” Transponder
- MST - Mini SSBL Transponders

The MPT / SPT transponders - are available with 1000, 3000 and 4000 m depth rating. Two types of low frequency MPT transponders are available with 6000 m depth rating. The MPT and SPT transponders do all have acoustic telemetry included. By use of acoustic telemetry from the HiPAP system several parameters can be controlled:

- Read battery status
- Enable / disable
- Transmitter power
- Receiver sensitivity
- Change channel - frequency
- Read sensors, if any
- Acoustic release

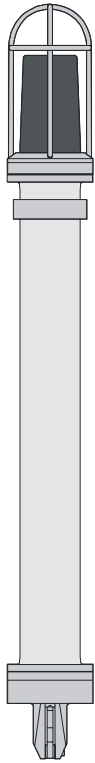
The MPT “Shorty” transponders - are based on the standard MPT transponders and can be field-rebuild.

The MST - are available with 1000, 2000 and 4000 m depth rating.

For details, please see the *Product Specification* for each of the models.

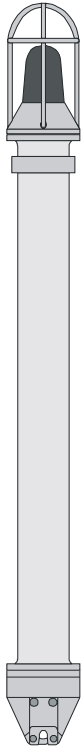
MPT series

The MPT series consists of a wide number of transponders all suited for SSBL and LBL use. Depth rating, beam pattern, release mechanism, pressure and temperature sensor are among the options / choices available.



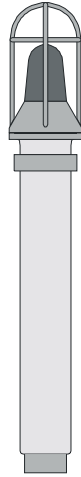
1835 mm

MPT 331/DTR DuB



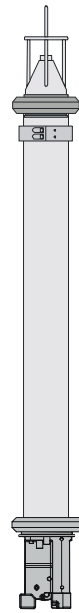
1800 mm

MPT 339/DTR



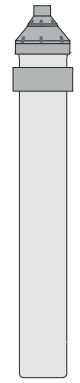
1140 mm

**MPT 339/
R 110 Vac**



1470 mm

MPT 319/R



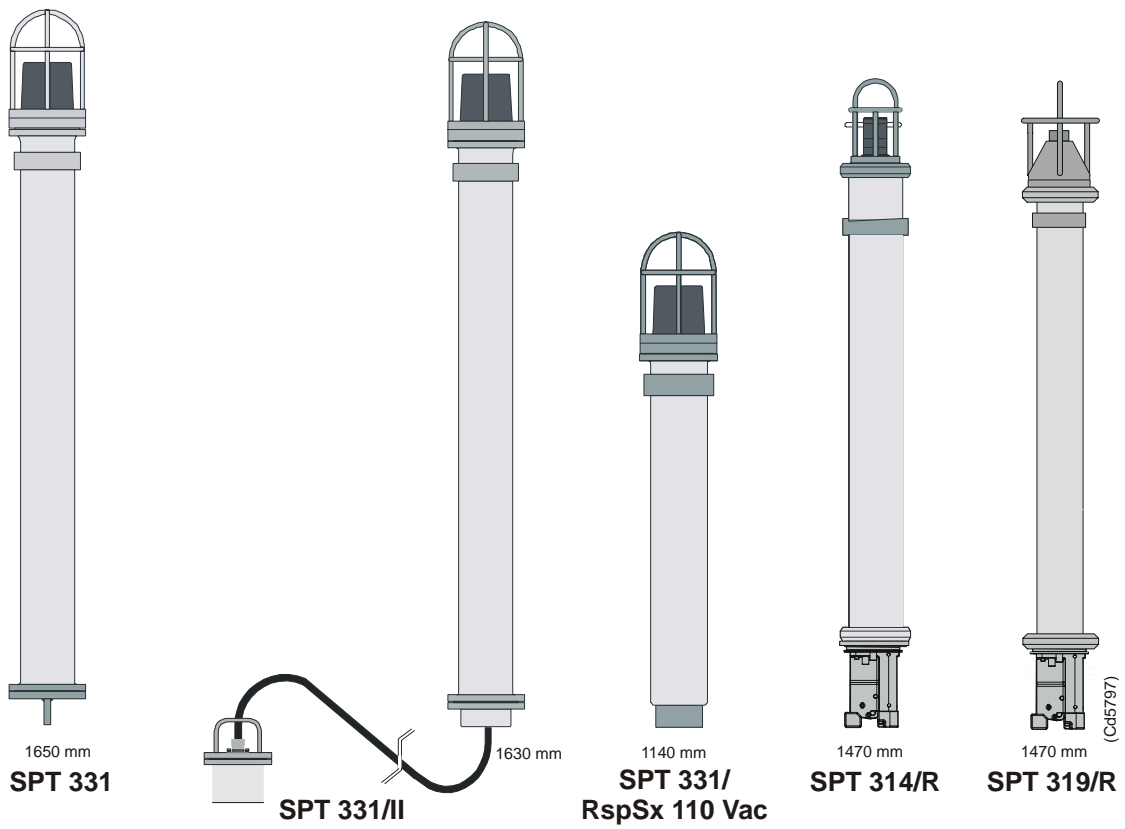
905 mm

MPT 316/DT EEx

(Cd5792)

SPT series

The SPT series consists of a wide number of transponders. All suited for SSBL use. The SPT has the same hardware as the MPT, but only the SSBL functionality. Depth rating, beam pattern, release mechanism, inclinometers, pressure and temperature sensor are among the options / chooses available.



MPT 341 “Shorty” series

The medium frequency MPT 341 “Shorty” series transponders, are transponders designed for shorter duration subsea jobs, like subsea construction applications - small size, light weight, but full MPT capability. This means:

- All models have an acoustic telemetry link for command and data transfer.
- All units are designed for ROV manipulator handling.
- The transponder unit is designed with a modular construction such that the transducer, transponder electronics, battery pack and options (where applicable) can be replaced individually.
- The MPT “Shorty” transponder can be field-rebuild.



MST series

The MST is an SSBL mini transponder suited for ROV operation and where the size of the transponder can be a limiting factor. The transponder models cover various water depths. The MST series consists of the following models:

- MST 319 - rated for 1000 m water depth
- MST 324 - rated for 2000 m water depth
- MST 342 - rated for 4000 m water depth

All units have a rechargeable battery, can operate in responder mode and can also be externally powered.



(C06424b)

SYSTEM FUNCTIONS

Introduction

The HiPAP system consists of a wide range of functions. A function is selected by the operator. The basic systems have standard functions included, to ensure normal operation. The systems may be delivered with additional options selected from the system option list.

Main functions

General

The main functions in the HiPAP system are described below. The system may be configured with one or several of these functions. They will appear in the systems main menu.

List of main functions

The list below shows which functionality each of the functions includes. The "reg. no" is the unique identification for this function.

Example; the reg. no for APOS Base version is 886 - 212745.

Reg. no	Description
886-212745	<p>APOS Base Version</p> <p><i>APOS - Acoustic Position Operator Station</i></p> <p>Base for running all applications, includes:</p> <ul style="list-style-type: none"> • Sound velocity profile function • Ethernet interface for position data • Serial line, RS-422 for transceiver interface • Serial line, RS-422 for position data <p>Transponder telemetry for SPT/MPT transponders including:</p> <ul style="list-style-type: none"> • Set transmit power level • Set receive sensitivity • Change channel • Enable/Disable • Transponder release • Read battery status • Read sensor data, if any <p>Position and angle alarm:</p> <ul style="list-style-type: none"> • APOS software for HiPAP providing alarm for transponder position and riser angle alarm. <p>APOS Depth sensor interface:</p> <ul style="list-style-type: none"> • APOS software for interfacing a depth sensor for depth compensation of position. Suitable for ROV or Tow fish positioning. <p>Interface to DGPS for providing data to transducer alignment:</p> <ul style="list-style-type: none"> • An SSBL transponder position can be presented in geographical coordinates. • The clock may be synchronised to 1PPS from the DGPS receiver.

Reg. no	Description
886-212746	<p>HiPAP 500 SSBL function</p> <p>APOS software for HiPAP 500 SSBL operation includes:</p> <ul style="list-style-type: none"> • Transponder positioning • Responder positioning • Serial interface for gyro and vru or attitude sensor - maximum 3 units • SSBL simulator for training
886-212747	<p>HiPAP 350 SSBL function</p> <p>APOS software for HiPAP 350 SSBL operation includes:</p> <ul style="list-style-type: none"> • Transponder positioning • Responder positioning • Serial interface for gyro and vru or attitude sensor - maximum 3 units • SSBL simulator for training
886-212748	<p>LBL function</p> <p>APOS software for LBL operation using HiPAP or HPR 400 includes:</p> <ul style="list-style-type: none"> • Calibration of transponder array in local grid • Positioning of vessel / ROV in LBL array • Necessary transponder telemetry • LBL simulator for training • Geographical position output if origin is entered in geo coordinates <p>On HiPAP it requires HiPAP SSBL function reg. no: 212746 / 212747.</p> <p>Positioning of an ROV in LBL requires an HPR 400 Subsea Unit.</p>
886-212750	<p>HiPAP MULBL function</p> <p>APOS software for HiPAP MULBL operation includes:</p> <ul style="list-style-type: none"> • Calibration of transponder array in local grid • Positioning of vessel in MULBL array • Necessary transponder telemetry <p>It requires HiPAP SSBL and LBL, reg. no.: 212746 and 12748.</p>

Reg. no	Description
ADDITIONAL OPTIONS	
886-212752	<p>Beacon Mode</p> <p>APOS software for HiPAP or HPR 400 beacon and depth beacon operation.</p>
886-212753	<p>Inclinometer Mode</p> <p>APOS software for HiPAP or HPR 400 inclinometer transponder operation.</p>
886-212754	<p>Compass Transponder</p> <p>Mode APOS software for HiPAP or HPR 400 compass transponder operation.</p>
886-212755	<p>GEO LBL Calibration</p> <p>APOS software for HiPAP or HPR 400 for calibration of LBL array in geographical coordinates. In positioning mode the position may be reported in geographical coordinates. It requires DGPS interface: 212756.</p>
886-212757	<p>LBL Transponder Positioning Mode</p> <p>APOS software for HiPAP or HPR 400 for use of MPT transponders to be positioned in an LBL network. (old name was Tp Range Pos).</p>
886-212758	<p>DUAL HiPAP SSBL function</p> <p>APOS and HiPAP software for dual SSBL operation. Provides simultaneous measurement of transponder position by use of two HiPAP transducers, includes:</p> <ul style="list-style-type: none"> • Dual HiPAP provides increased accuracy • Transponder positioning • Responder positioning • Provides two separate and one integrated position <p>Requires two HiPAP transceivers/transducers for SSBL operation.</p>
886-212759	<p>APOS Master Slave function</p> <p>An extra copy of the functionality of the master operator station for installation on additional operator stations.</p> <p>The operator can select which station shall be the master. it can be used for both HiPAP and HPR 400 systems.</p>

Reg. no	Description
886-212760	<p>APOS Upgrade software</p> <p>Upgrade from HSC 400 software to APOS software, including old functionality. This may require a new monitor and an APC 10 computer and keyboard.</p>
886-212761	<p>APOS External synch.</p> <p>APOS software for synchronising the HiPAP or HPR 400 transceivers to external equipment.</p>
886-212763	<p>HiPAP Transceiver DUAL Ethernet</p> <p>An SDN 400 module mounted in HiPAP transceiver cabinet for interface to dual Ethernet.</p>
886-212765	<p>APOS ACS BOP function</p> <p>APOS software for telemetry to ACS 400 used on BOP. Telemetry to ACS 300 only available on HPR 400 systems.</p>
886-212766	<p>APOS ACS OLS function</p> <p>APOS software for telemetry to ACS 300 system used on OLS. Telemetry to ACS 300 only available on HPR 400 systems.</p>
886-212767	<p>APOS STL function</p> <p>APOS software for HiPAP or HPR 400 systems for STL fields special functions including:</p> <ul style="list-style-type: none"> • Scanning of MLBE depth and position • Positioning of STL buoy • Scanning of transponder battery status • Graphics showing STL connection point
886-215836	<p>APOS Anchor Line Monitoring function</p> <p>APOS software for HiPAP and HPR 400 systems. Scanning of up to 9 transponder(s) installed on Anchor Lines/Anchor Line Buoys, presenting individual:</p> <ul style="list-style-type: none"> • Depth • Position • Scanning of transponder battery status
886-215837	<p>HiPAP Transponder Relay Function</p> <p>Enables use of relay-function, relay-transponder frequency allocation, operator interfaces and displays functionality.</p>

Reg. no	Description
886-215939	<p data-bbox="461 421 922 454">SAL Tension & Yoke monitoring</p> <p data-bbox="461 472 1313 539">APOS software HiPAP or HPR 400 systems for showing Tension and Yoke including:</p> <ul data-bbox="501 568 1023 723" style="list-style-type: none"><li data-bbox="501 568 1023 607">• Graphical presentation of yoke-angle<li data-bbox="501 629 975 667">• Graphical presentation of tension<li data-bbox="501 689 1166 723">• Table for converting inclination angle to tension
886-212769	<p data-bbox="461 745 783 779">APOS Training version</p> <p data-bbox="461 797 1313 969">A CD containing the APOS software and a copy of the APOS manual. This is suitable for demonstrations and training purposes. The APOS can be operated as normal and a simulator replaces transceiver and transponders. It can also be used to check telegram interfaces.</p> <p data-bbox="461 992 1361 1059">This requires a computer with CD-ROM player, running NT40, and a monitor with 1024 x 768 resolution.</p>

TECHNICAL SPECIFICATIONS

SSBL accuracy

The angular figures are errors in both axis, elevation and orthogonal.

The specification is based on:

Note

The specification is based on:

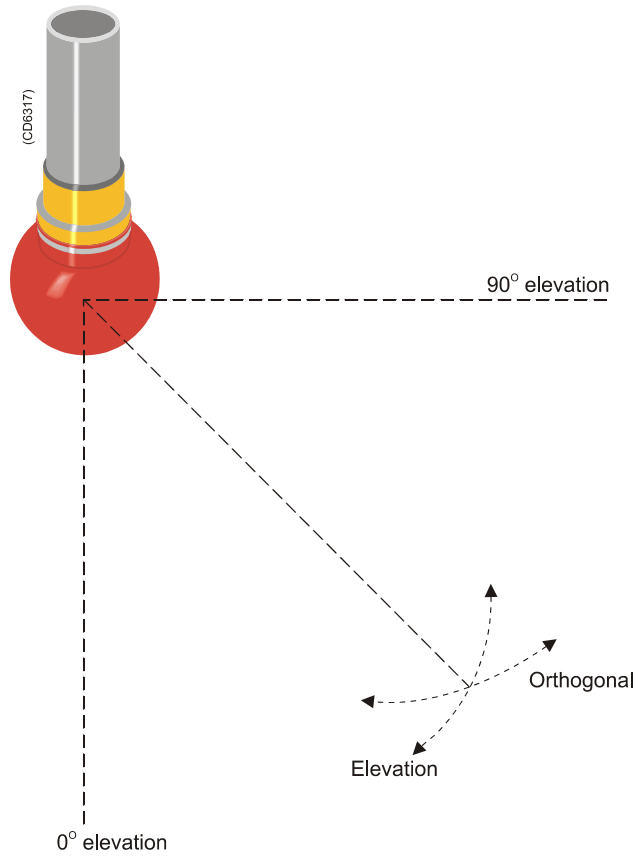
- Free line of sight from transducer to transponder.
- No influence from ray-bending.
- Signal to Noise ratio in water in the 250 Hz receiver band.
- No error from heading and roll / pitch sensors.

HiPAP 500

HiPAP 500 Single system	S/N [dB rel. 1 μ Pa]		
	20	10	0
Angular Accuracy [°] (At 0° elevation)	0.12	0.18	0.3
Range Accuracy [m]	0.1	0.15	0.2
Receiver beam [°]	10		
Coverage [°]	+/-100		

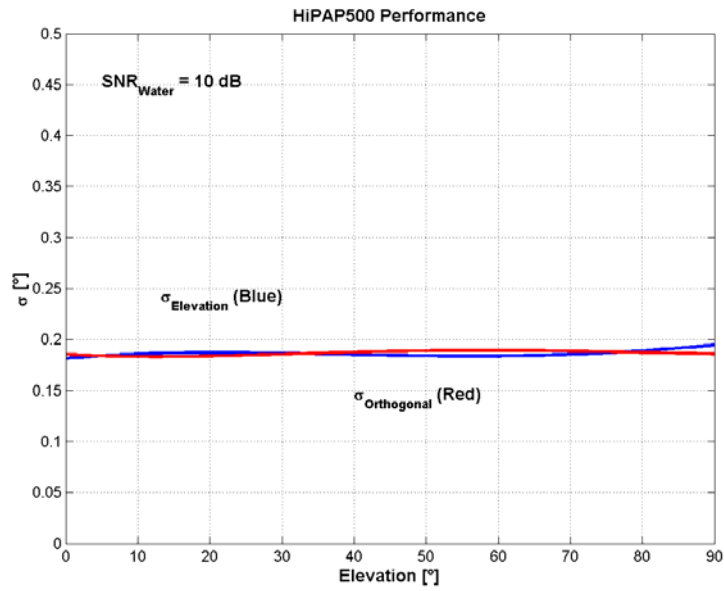
HiPAP 500 Dual system	S/N [dB rel. 1 μ Pa]		
	20	10	0
Angular Accuracy, 1 σ [°] (At 0° elevation)	0.085	0.13	0.21
Range Accuracy, 1 σ [m]	0.1	0.15	0.2
Receiver beam [°]	10		
Coverage [°]	+/-100		

Definition of elevation and orthogonal – HiPAP 500

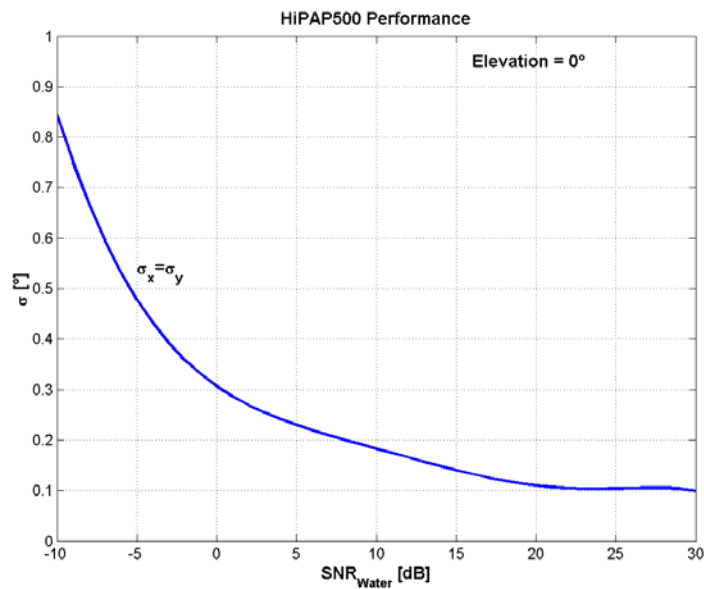


The elevation and orthogonal angles are used in the accuracy curves.

Accuracy curves – HiPAP 500



The figure above shows the accuracy as a function of elevation angle. The signal to noise ratio of 10 dB is in the bandwidth.



The figure above shows the accuracy as a function of signal to noise ratio. The elevation and the orthogonal angles are 0° (at vertical).

HiPAP 450

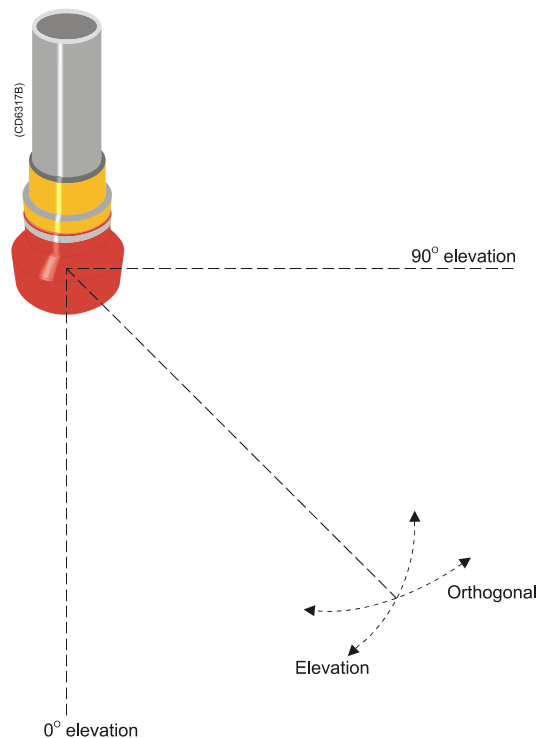
Same as for HiPAP 350.

→ Refer to HiPAP 350 SSBL accuracy.

HiPAP 350

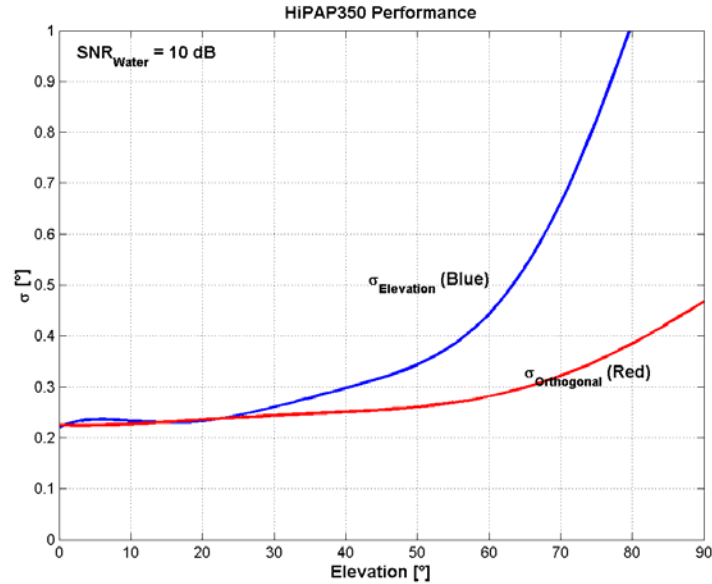
HiPAP 350/450 Single system	S/N [dB rel. 1 μ Pa]		
	20	10	0
Angular Accuracy, 1 σ [°] (At 0° elevation)	0.18	0.23	0.4
Range Accuracy, 1 σ [m]	0.1	0.15	0.2
Receiver beam [°]	15		
Coverage [°]	+/-80		

Definition of elevation and orthogonal – HiPAP 350

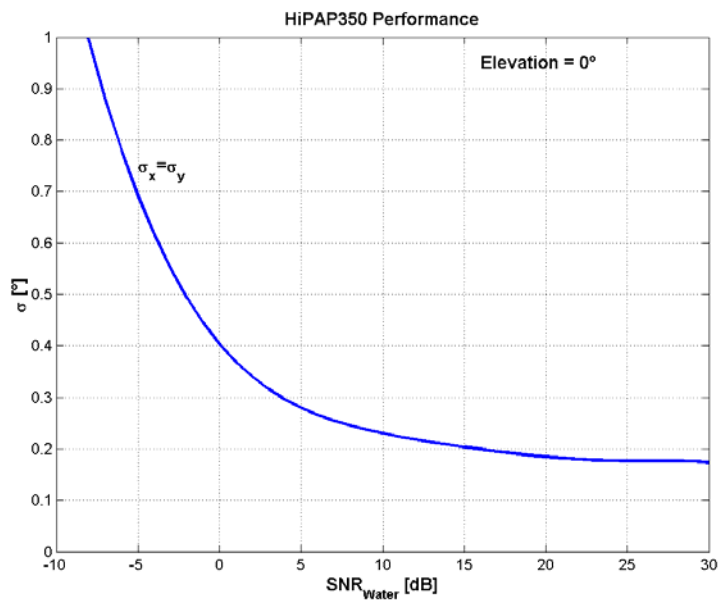


The elevation and orthogonal angles are used in the accuracy curves.

Accuracy curves – HiPAP 350



The figure above shows the accuracy as a function of elevation angle. The signal to noise ratio 10 dB is in the bandwidth.



The figure above shows the accuracy as a function of signal to noise ratio. The elevation and the orthogonal angles are 0° (at vertical).

LBL accuracy

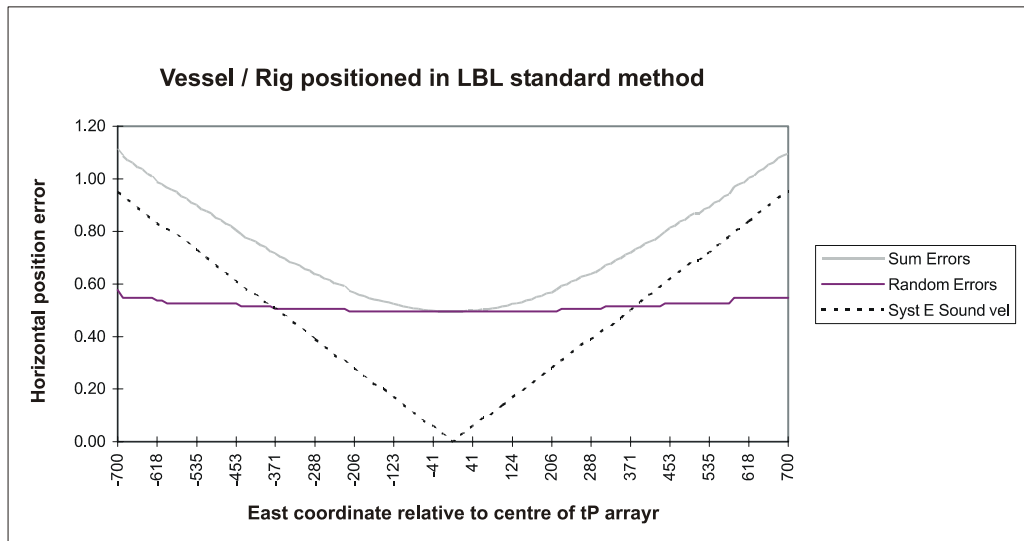
The position accuracy for LBL operation is very dependent on the transponder array geometry, sound velocity errors and signal to noise ratio. However, the accuracy can be shown by simulations.

Range accuracy's down to a few centimetres can be obtained, while ROV and vessel positions can be calculated to within a few decimetres.

The following "one sigma" error contribution to the range measurements is assumed (20-30 kHz system):

- Range reception with 20 dB S/N: 0.15 m
- Range reception in the transponder: 0.15 m
- Range error due to TP movement: 0.10 m
- Range error due to rig movement: 0.20 m

The random errors are added as Gaussian noise to the measurements.



(Cd5534)

Figure 8 Error in the horizontal position

The figure above shows the error in the horizontal position when the Rig moves within the transponder array. The simulations are done with the following parameters:

- Four LBL transponders placed on the seabed in a circle with radius 636 m.
- The water depth is 1200 m.

The error is showed as a function of the East coordinate. The north coordinate is retained at zero, and the East coordinate zero is consequently the centre of the array. We have assumed that the wide beam of the transducer is used, and that the S/N when receiving the transponder replies is 20 dB. The effect of a systematic error in the Sound velocity of 1 m/s is also showed. When being in the centre of the array, that error causes no position error. When being in the outer parts of the array, that error causes a significant systematic error in the position.

Range capabilities

The range capabilities are very dependent of the vessels noise level and attenuation of the transponder signal level due to ray bending.

- The HiPAP system will in most cases have longer range capabilities that specified below due to its narrow receiving beam.
- The figures are based on 20-32 kHz systems and are approximate values for guidance.

Standard transponder:

w/ 188 dB rel.1 μ Pa ref.1m	Typical max. 1500 m
---------------------------------	---------------------

High power transponder:

w/ 195 dB rel.1 μ Pa ref.1m	Typical max. 2000 m
---------------------------------	---------------------

High power transponder:

w/ 206 dB rel.1 μ Pa ref.1m	Typical max. 3000 m
---------------------------------	---------------------

Note

The specification is based on:

- Free line of sight from transducer to transponder
- No influence from ray bending
- Signal to Noise ratio \geq 20 dB. rel. 1 μ Pa

Unit specifications

APC 10 computer

General:

Unit for desktop installation	Approximately 17 kg
Unit for rack installation (including rails and side plates)	Approximately 17 kg
Colour graphics resolution	Eligible max. 1600 x 1200
Video output	15 pin, analogue VGA
Floppy drive	3.5"
Printer interface	parallel
Electrical interfaces	RS-422, RS-232, Ethernet

Power supply:

Voltage	180-264 Vac / 90-132 Vac
Frequency	50-60 Hz
Max Inrush current	80 A
Nominal	80 W

Environment:

Storage	-40° C to +70° C
Operating	+10° C to +55° C
Humidity Storage / operating	85% / 95% relative

Vibration:

Range	5-100 Hz
Excitation level	5-13.2 Hz \pm 1.5 mm, 13.2-100 Hz 1 g

Telegram formats:

Serial lines	Ethernet
- Proprietary NMEA	- Proprietary NMEA

Keyboard

Weight	0.5 kg
Cable length	1.5 m
Degree of protection	IP65

Trackball

Weight	1.5 kg
Cable length	2.8 m
Degree of protection	IP64

Display 19" TFT

General:

Vertical frequency range	60 - 85 Hz
Horizontal frequency range	31.5 - 91.1 kHz
Supply current	0.7 - 1.7 A
Resolution	1280 x 1024 pixels
Weight	12 kg (w/bracket)

Environment:

Operating temperature	-15° C to +55° C
Storage temperature	-20° C to +60° C
Humidity operating / storage	30 - 90% relative / 10 - 90% relative

Power supply display:

Supply voltage	24 Vdc
----------------	--------

Power supply unit:

Input voltage	115/220 Vac
---------------	-------------

HiPAP transceiver unit

The following specifications are common for the HiPAP 500 and the HiPAP 350 transceiver units.

The HiPAP 450 system uses a HiPAP 500 Transceiver Unit.

Power supply:

Voltage	230 Vac +/-10%
Frequency	50-60 Hz
Inrush max	500 W
Nominal	250 W

Protection:

Degree of protection	IP 44
----------------------	-------

Operating temperature:

Standard (no cooling door)	0° C to +35° C
Allowable maximum temperature for a 12 hour period (no cooling door)	+55° C
With cooling door (309-216005)	0° C to +55° C

Environment:

Storage temperature	-20° C to + 65° C
Storage / operational humidity	90% / 80% relative

Note

The unit must be operating in a non-corrosive and dust-free atmosphere, with temperature and humidity within the specified limits.

Cooling unit

Height x width x depth	(320 x 110 x 520) mm
Weight	14.2 kg

HiPAP 500

Weight	Approximately 55 kg
--------	---------------------

HiPAP 350

Weight	Approximately 47 kg
--------	---------------------

Heading reference (both models)

- Serial RS-422 SKR format
- Serial RS-422 STL format
- Serial RS-422 NMEA format
- Serial RS-422 Seatex MRU or Seapath
- Serial RS-422 DGR format (Tokimec DGR 11)
- Serial RS-422 NMEA HDT, VHW
- Serial RS-422 SKR format

Roll and pitch reference (both models)

- Serial RS-422 Seatex MRU or Seapath

HiPAP hull units

The following specifications are common for all HiPAP hull units.

Power supply:

Voltage	230/440 Vac 3-phase
Frequency	50-60 Hz
Consumption max.	1100 W

Environment:

Storage	-20° C to +60° C
Operating	0° C to +55° C
Storage / operating humidity	90% / 80% relative

Protection:

Degree of protection	IP 54
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Weight:

HL 3770 (standard with 500 mm dock)	1225 Kg
HL 2180 (without transducer dock)	950 Kg
HL 3770 (standard with 350 mm dock)	1200 Kg
HL 4570(including dock and transducer)	1430 Kg
HL 6120 (extra long transducer shaft)	1575 Kg

Hoist Control Unit

Weight	12 kg
Degree of protection	IP 54

Power supply:

Voltage	230 / 440 Vac 3 Phase
Frequency	50-60 Hz
Consumption max.	1100 W

Environment:

Storage	-20° C to +60° C
Operating	0° C to +55° C
Storage / operating humidity	90% / 80% relative

Remote Control Unit

Weight	1.5 kg
Degree of protection	IP 54

Power supply:

The Remote Control Unit is supplied with 24 Vdc from the Hoist Control Unit.

Voltage	240 Vdc
Frequency	50-60 Hz
Consumption	6 W

Temperature:

Storage	-20° C to +60° C
Operating	0° C to +55° C

Humidity:

Storage	10 - 90% relative
Operational	30 - 80% relative

Flanges

Certificates

Lloyd's and DNV certifications are standard, others on request.

500 mm mounting flange

Standard height	600 mm
Optional height	Specified by customer
Internal diameter	500 mm
Flange diameter	670 mm
Wall thickness	20 mm
Weight, standard	Approximately 90 Kg

350 mm mounting flange

Standard height	200 mm
Optional heights	Specified by customer
Internal diameter	350 mm
Flange diameter	505 mm
Wall thickness	28 mm
Weight, standard	Approximately 70 Kg

Gate valves**Certificates**

Lloyd's and DNV certifications are standard, others on request.

500 mm gate valve

Type	DN500
Height	350 mm
Length (from centre)	1335 mm
Internal diameter	500 mm
Flange diameter	670 mm
Weight	510 Kg

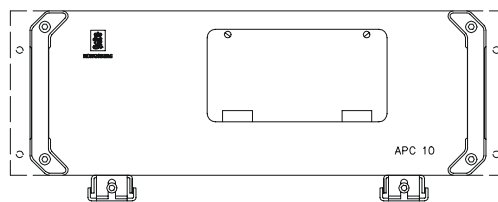
350 mm gate valve

Type	DN350
Height	290 mm
Length (from centre)	940 mm
Internal diameter	350 mm
Flange diameter	505 mm
Weight	225 Kg

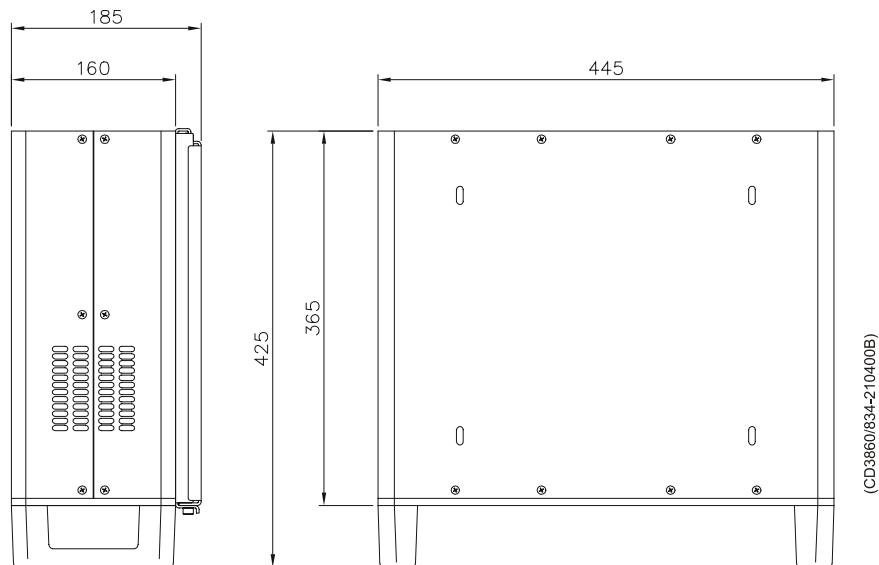
Outline dimensions

The outline dimensions shown in this section are for information only and must not be used for installation or manufactory purposes. For exact information, please use the installation manuals.

APC 10 computer



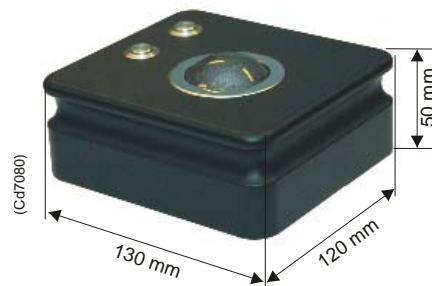
All measurements in mm.



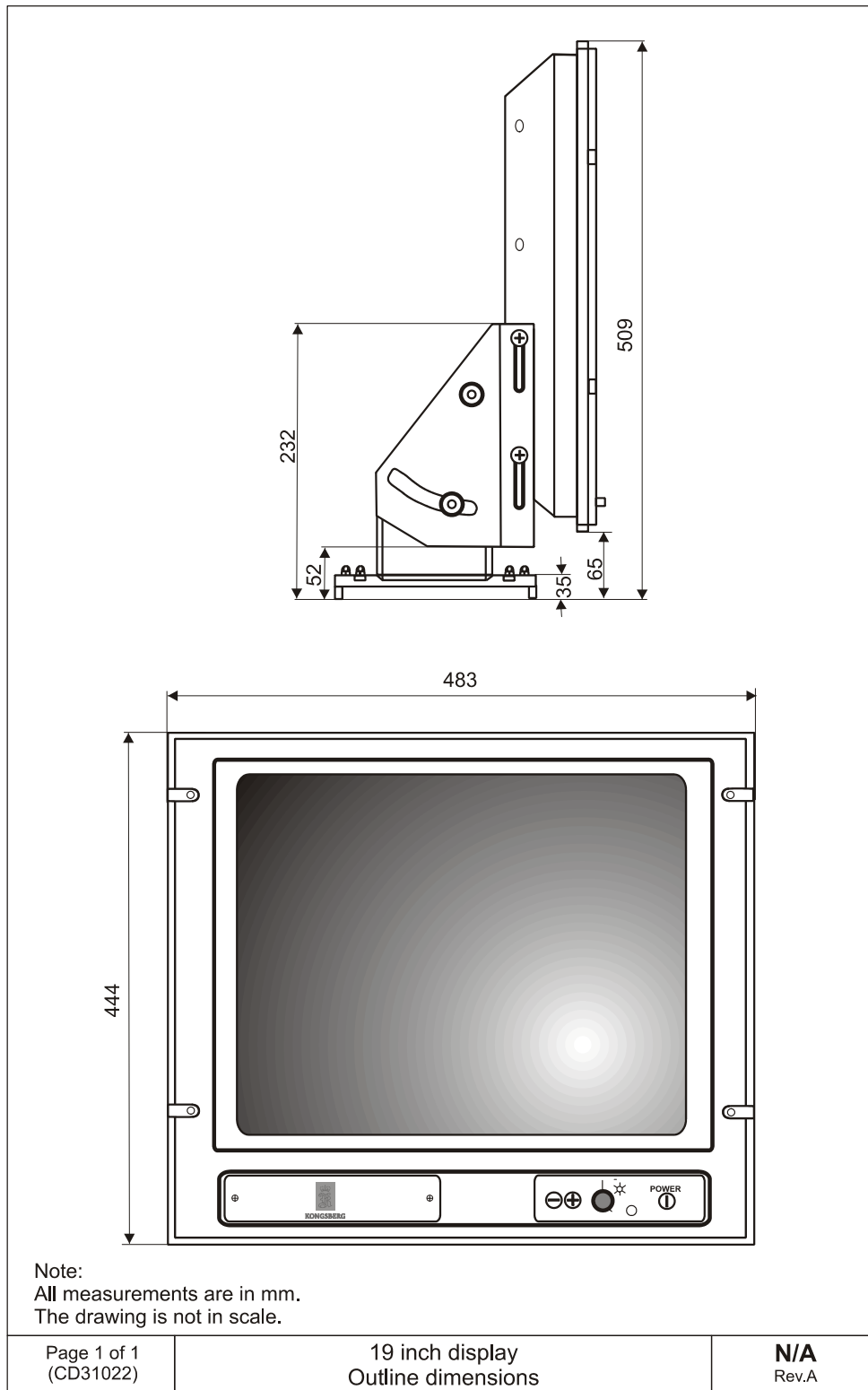
Keyboard



Trackball



19" TFT display



Note:
 All measurements are in mm.
 The drawing is not in scale.

Page 1 of 1
 (CD31022)

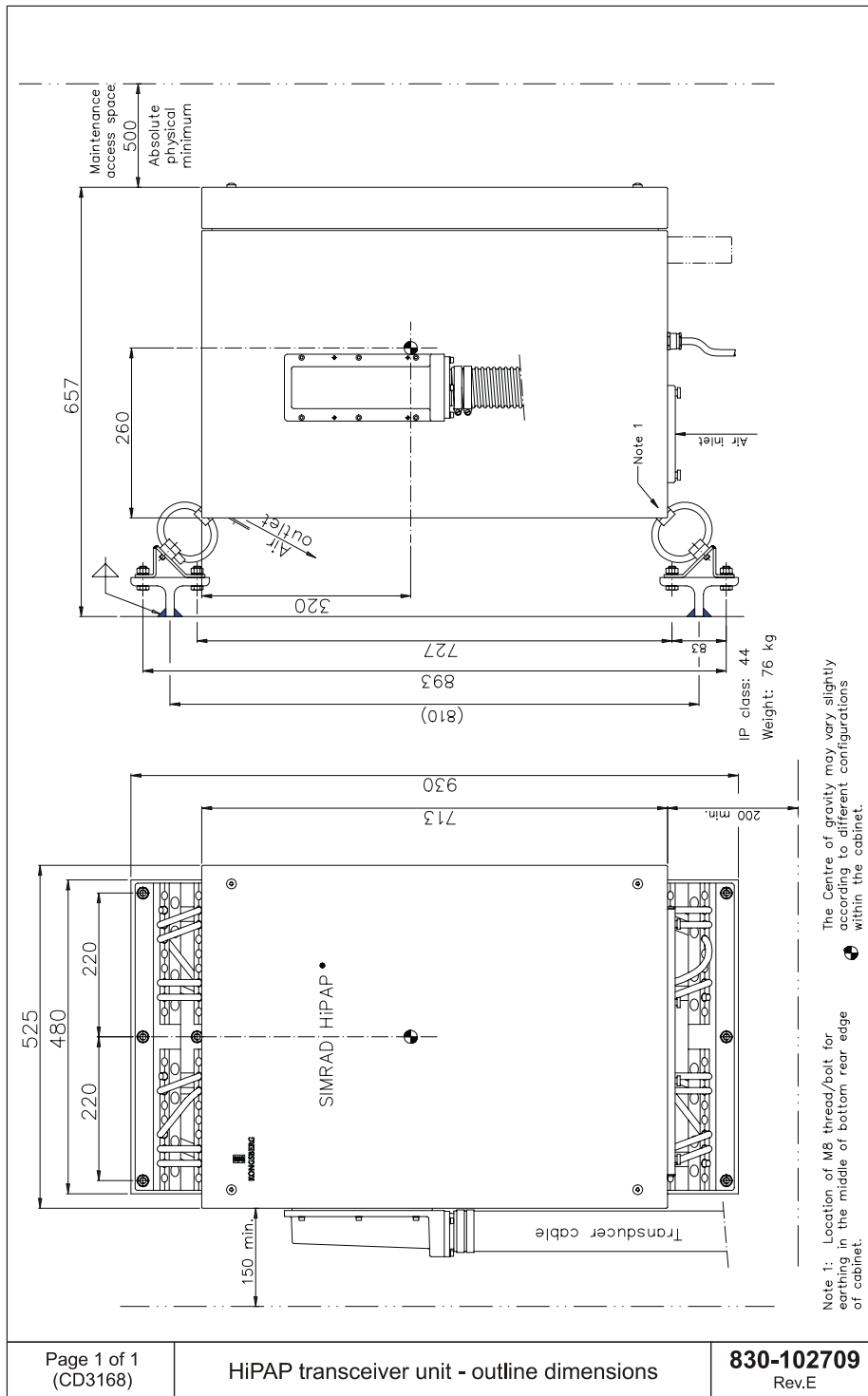
19 inch display
 Outline dimensions

N/A
 Rev.A

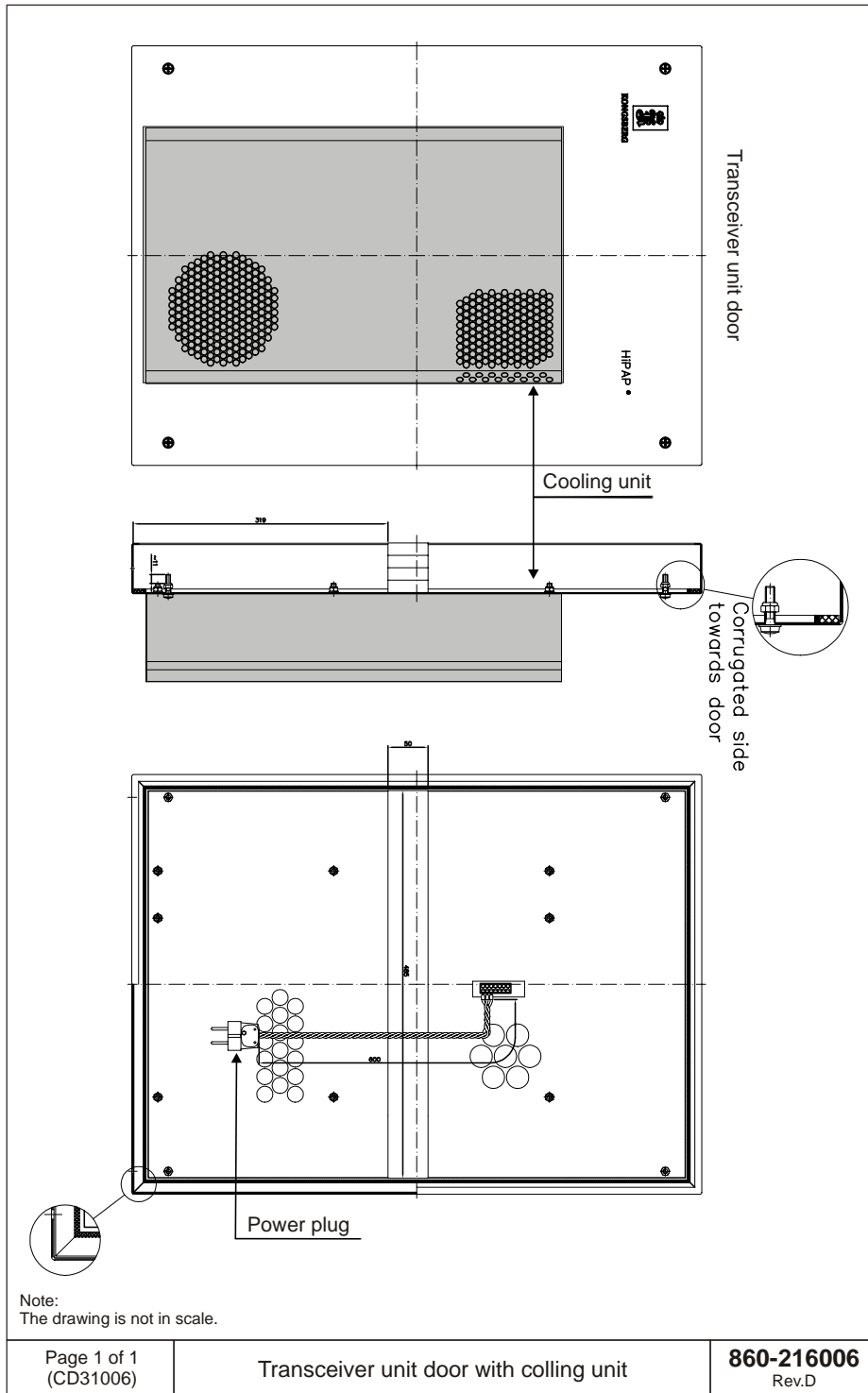
Operator console



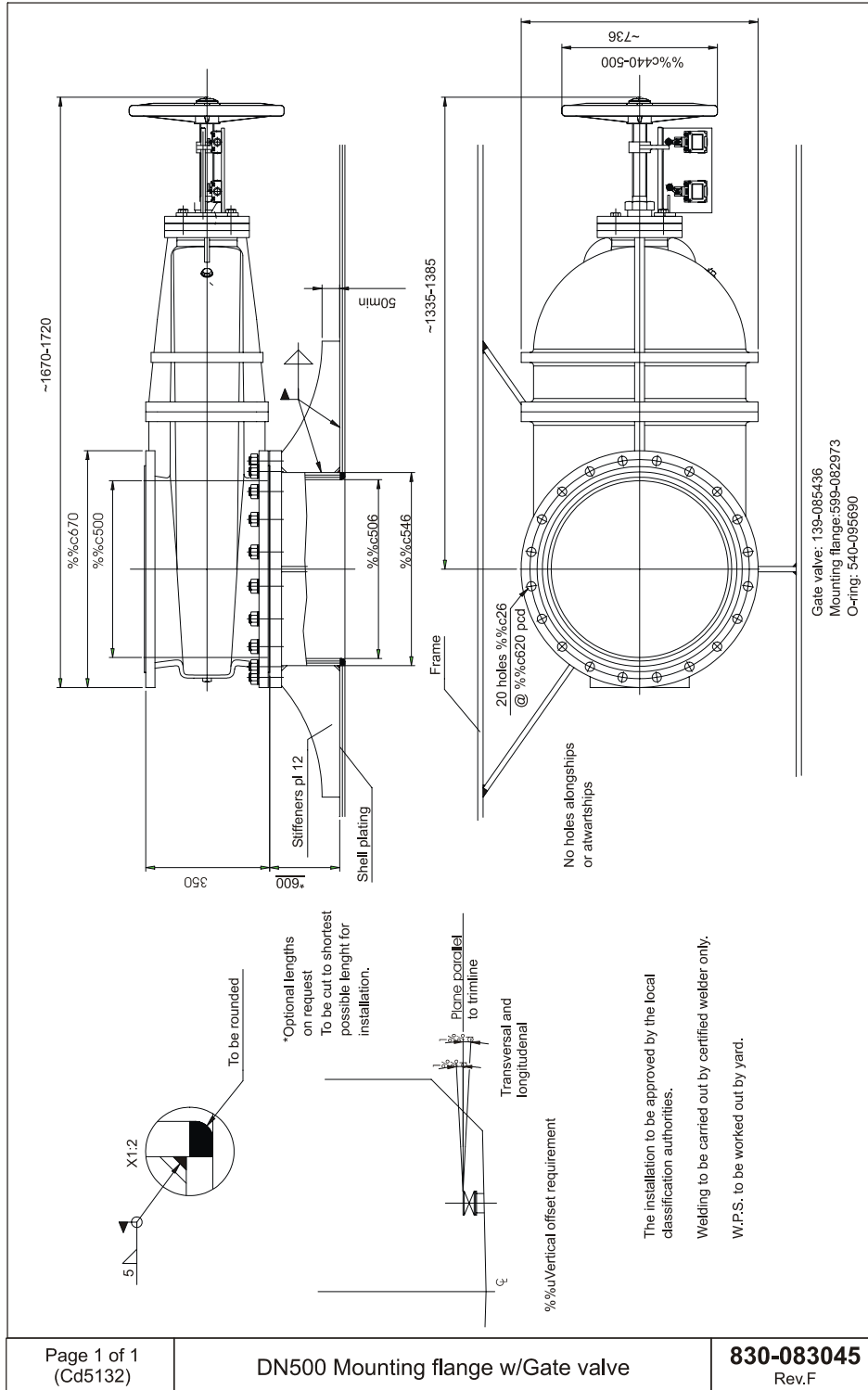
HiPAP transceiver unit – outline dimensions



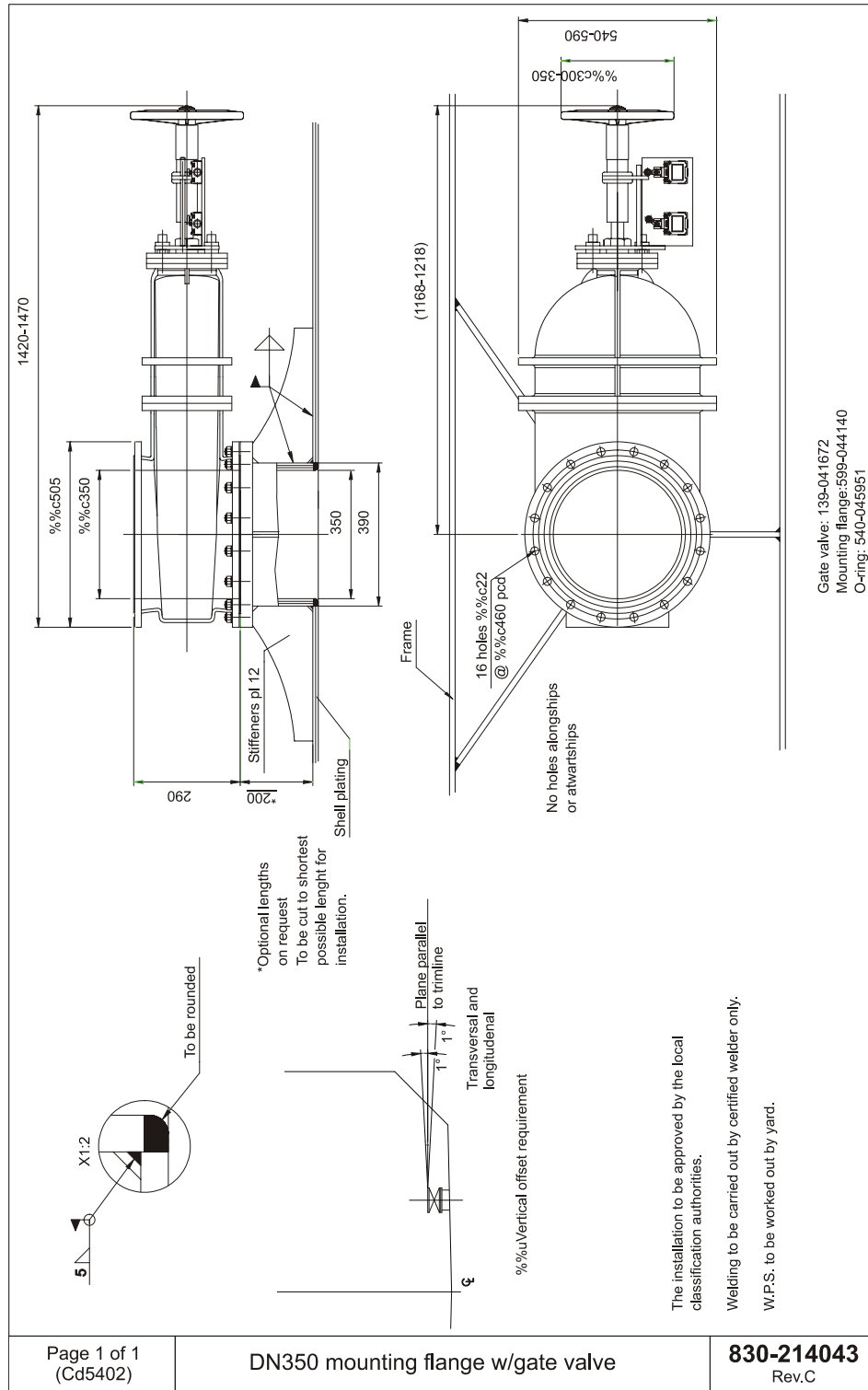
HiPAP transceiver unit door w/cooling unit



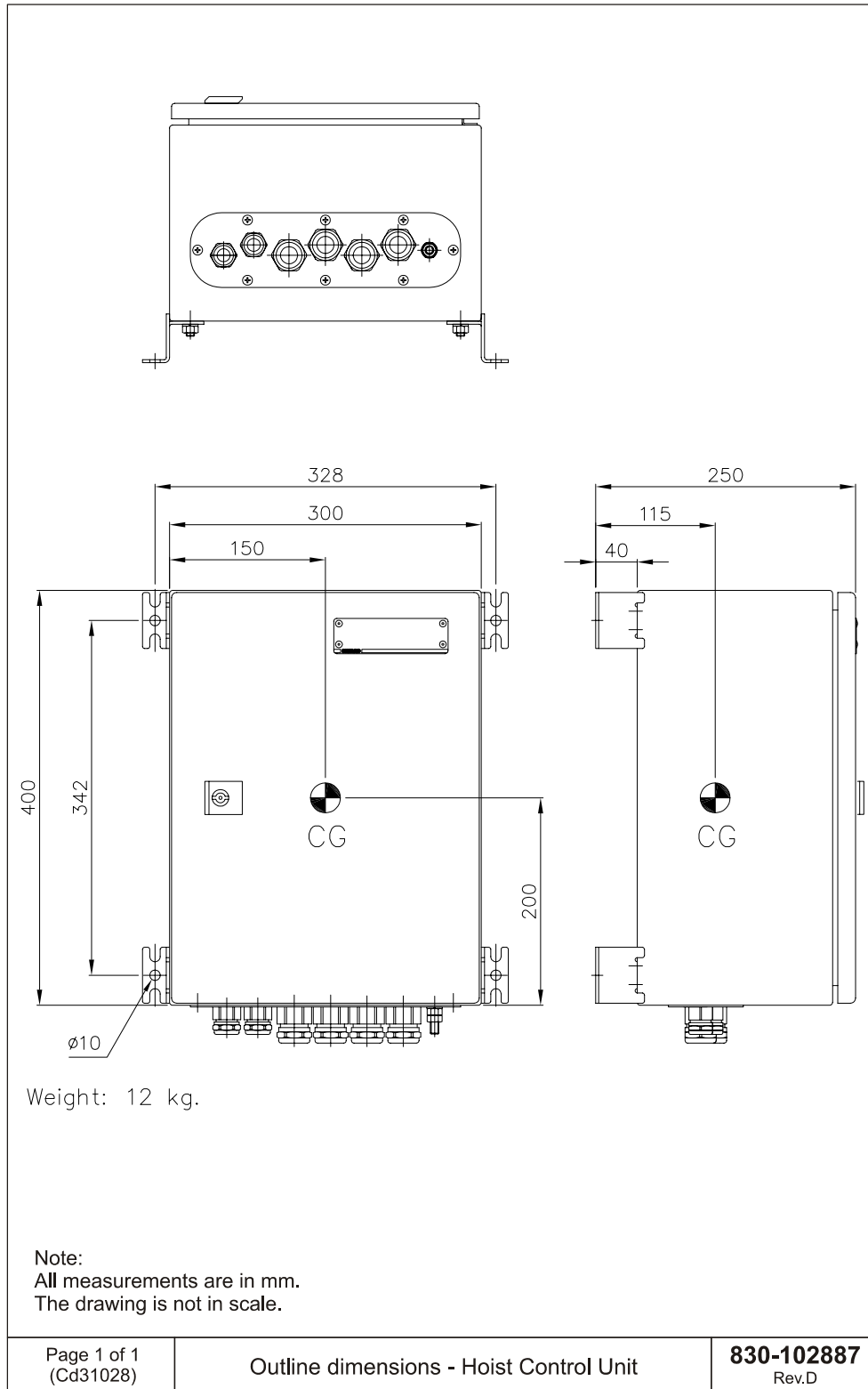
Gate valve and flange – 500 mm



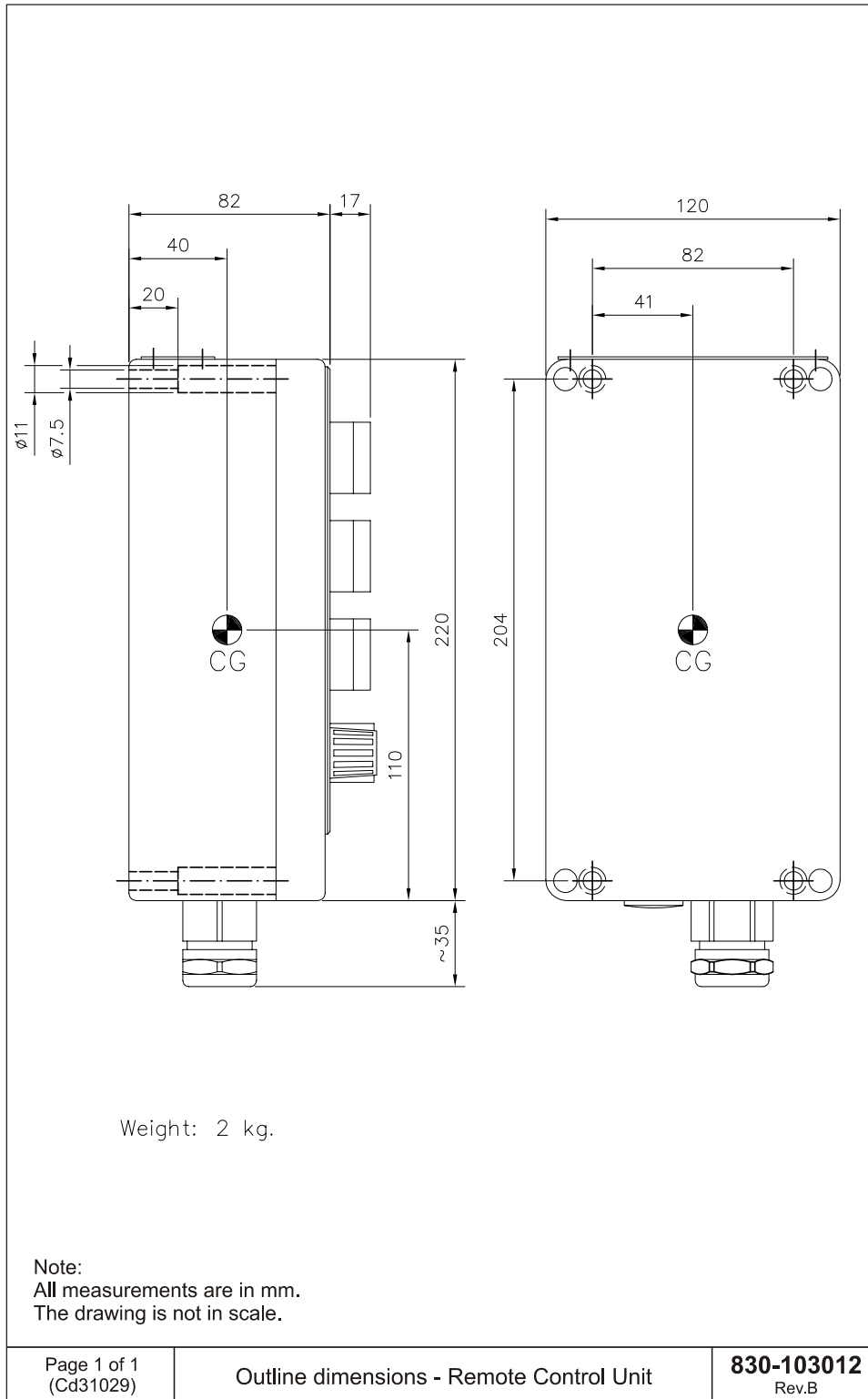
Gate valve and flange – 350 mm



Hoist Control Unit



Remote Control Unit



HiPAP hull units

The following hull units outline dimensions are included:

HiPAP 500

- HiPAP 500 HL 2180, see page 65.
- HiPAP 500 HL 2180 without dock and gate valve, see page 66.
- HiPAP 500 HL 3770, see page 67.
- HiPAP 500 HL 4570, see page 68.
- HiPAP 500 HL 6120, see page 69

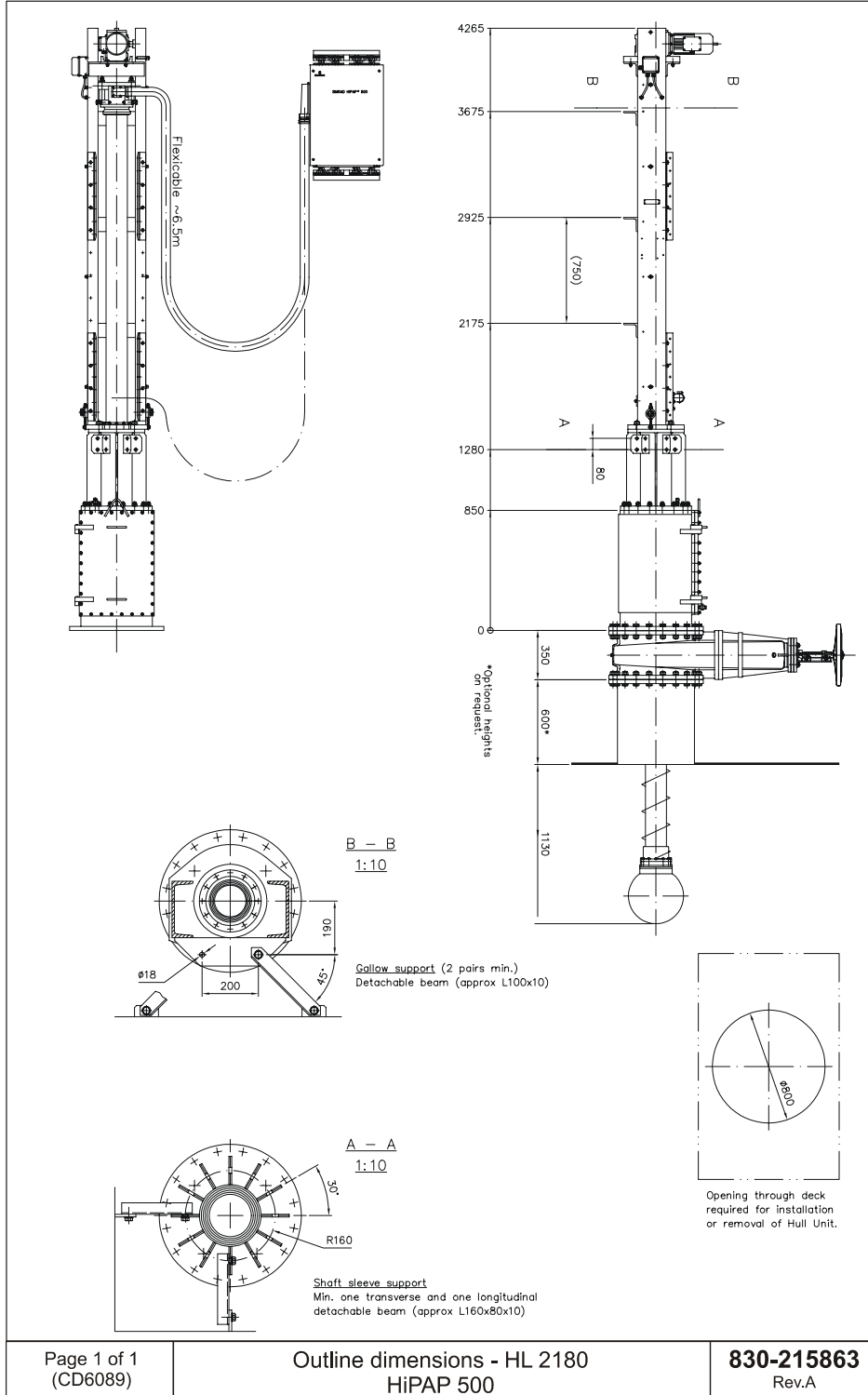
HiPAP 450

The HiPAP 450 uses the HiPAP 500 hull units.

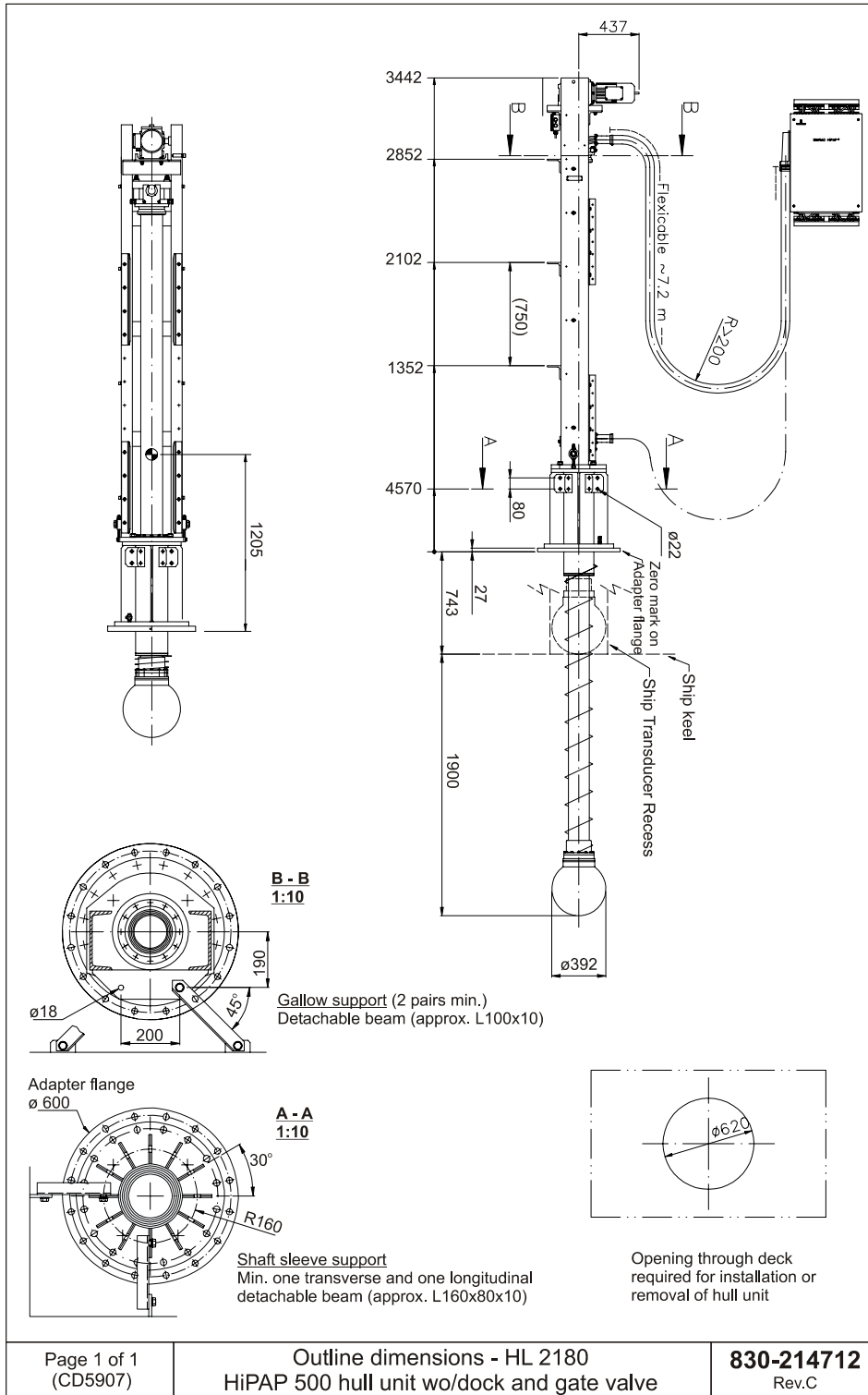
HiPAP 350

- HiPAP 350 HL 2180, see page 70.
- HiPAP 350 HL 3770, see page 71.
- HiPAP 350 HL 6120, see page 72.

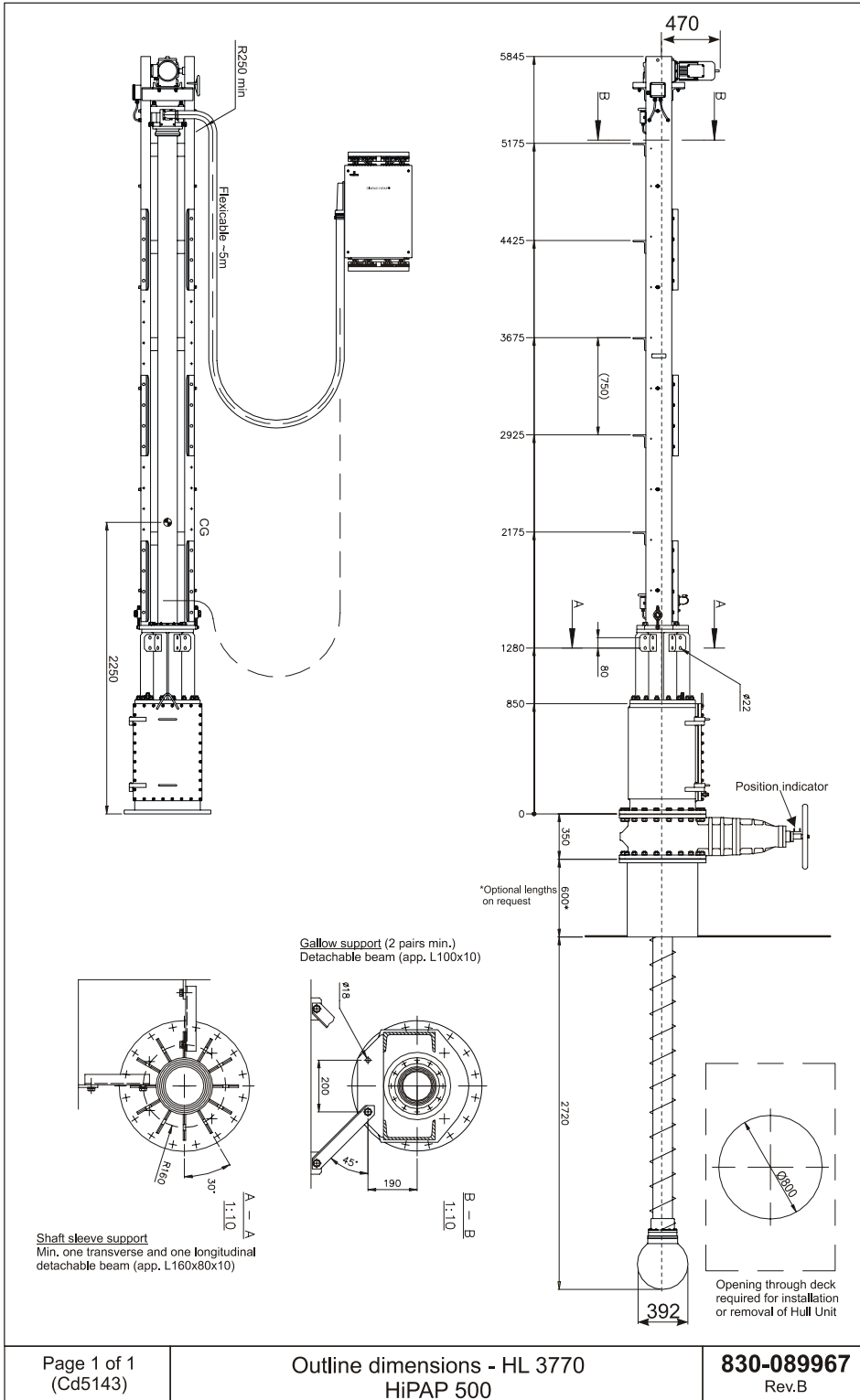
HiPAP 500 HL 2180



HiPAP 500 HL 2180 without dock and gate valve



HiPAP 500 HL 3770

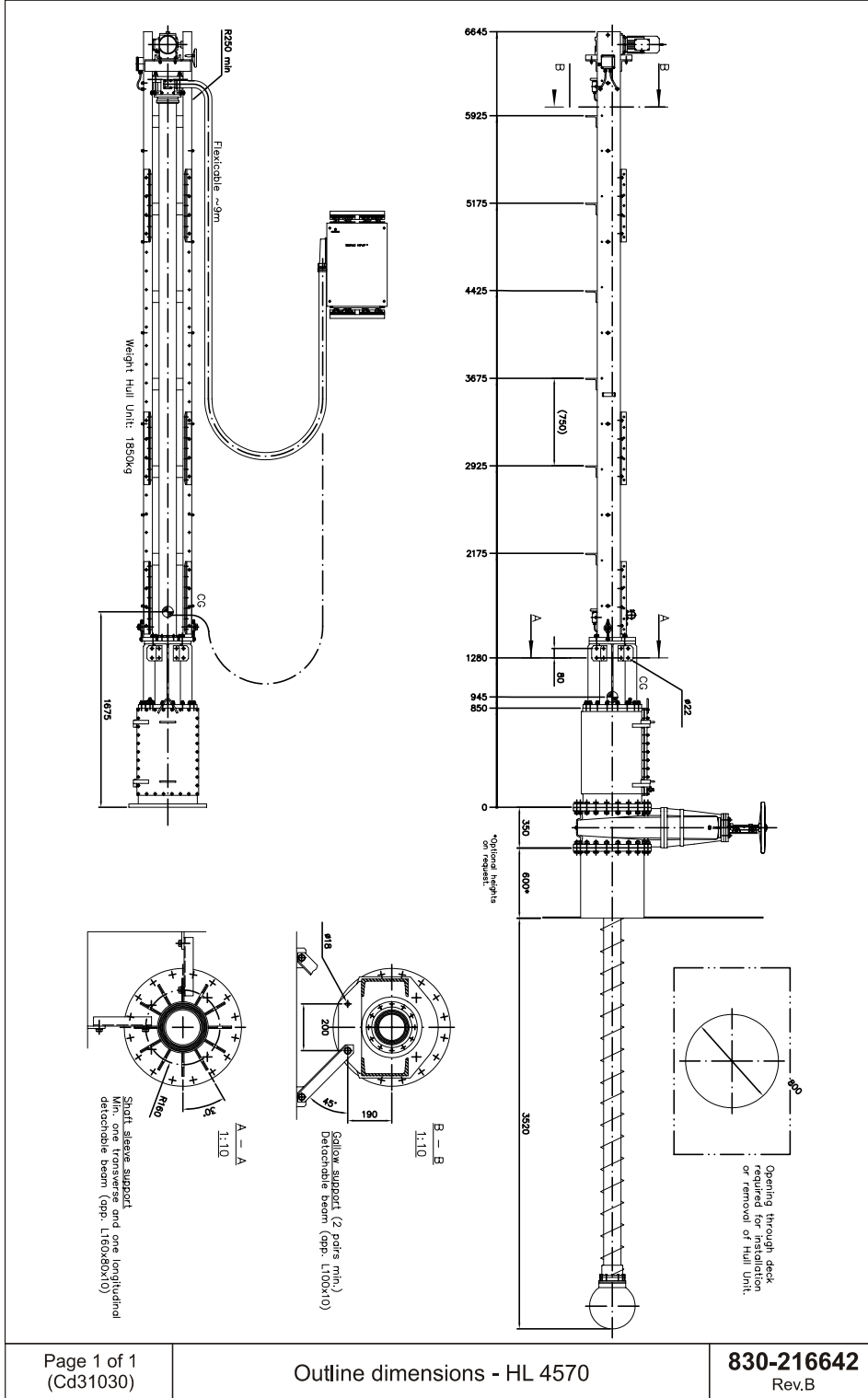


Page 1 of 1
(Cd5143)

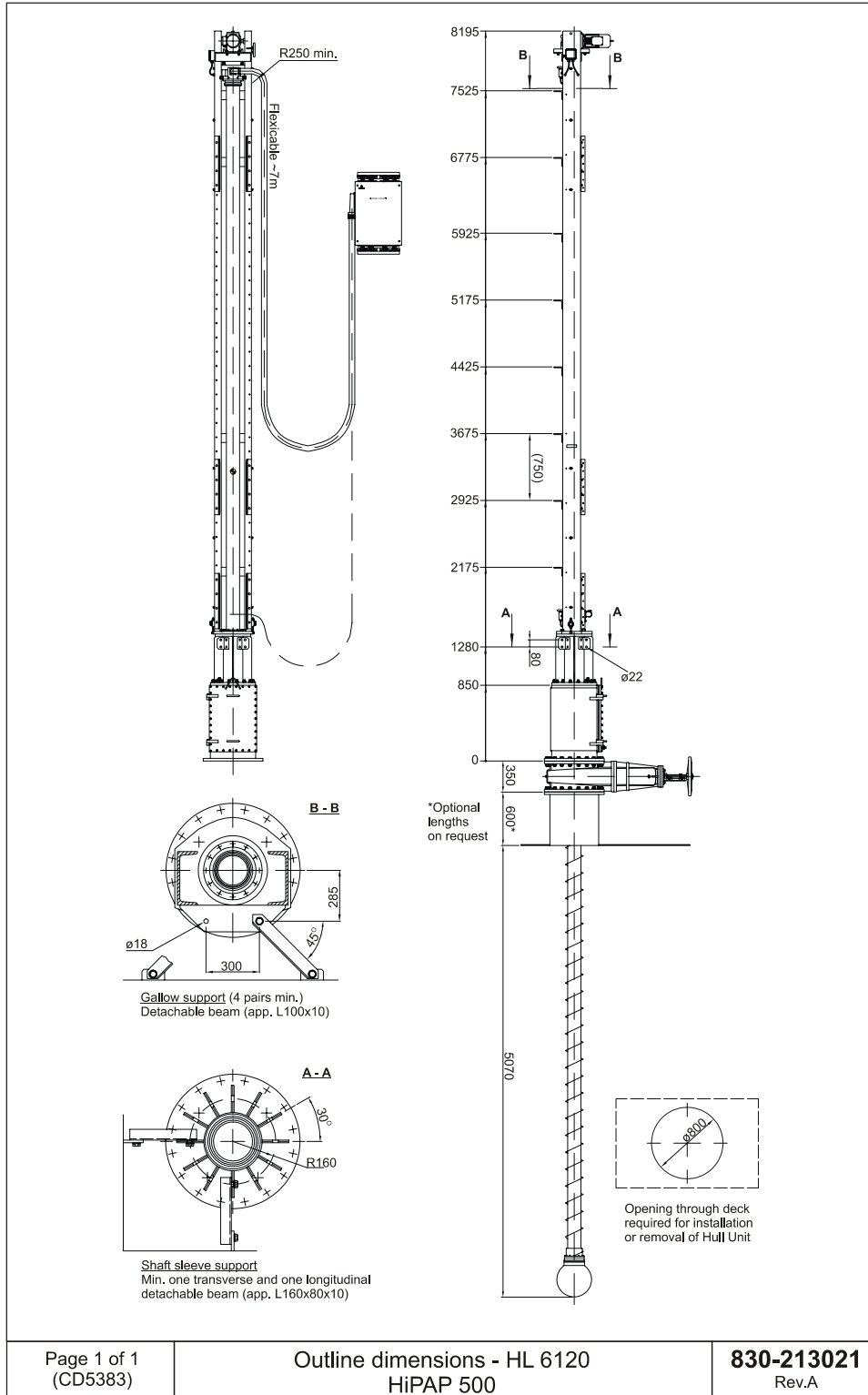
Outline dimensions - HL 3770
HiPAP 500

830-089967
Rev.B

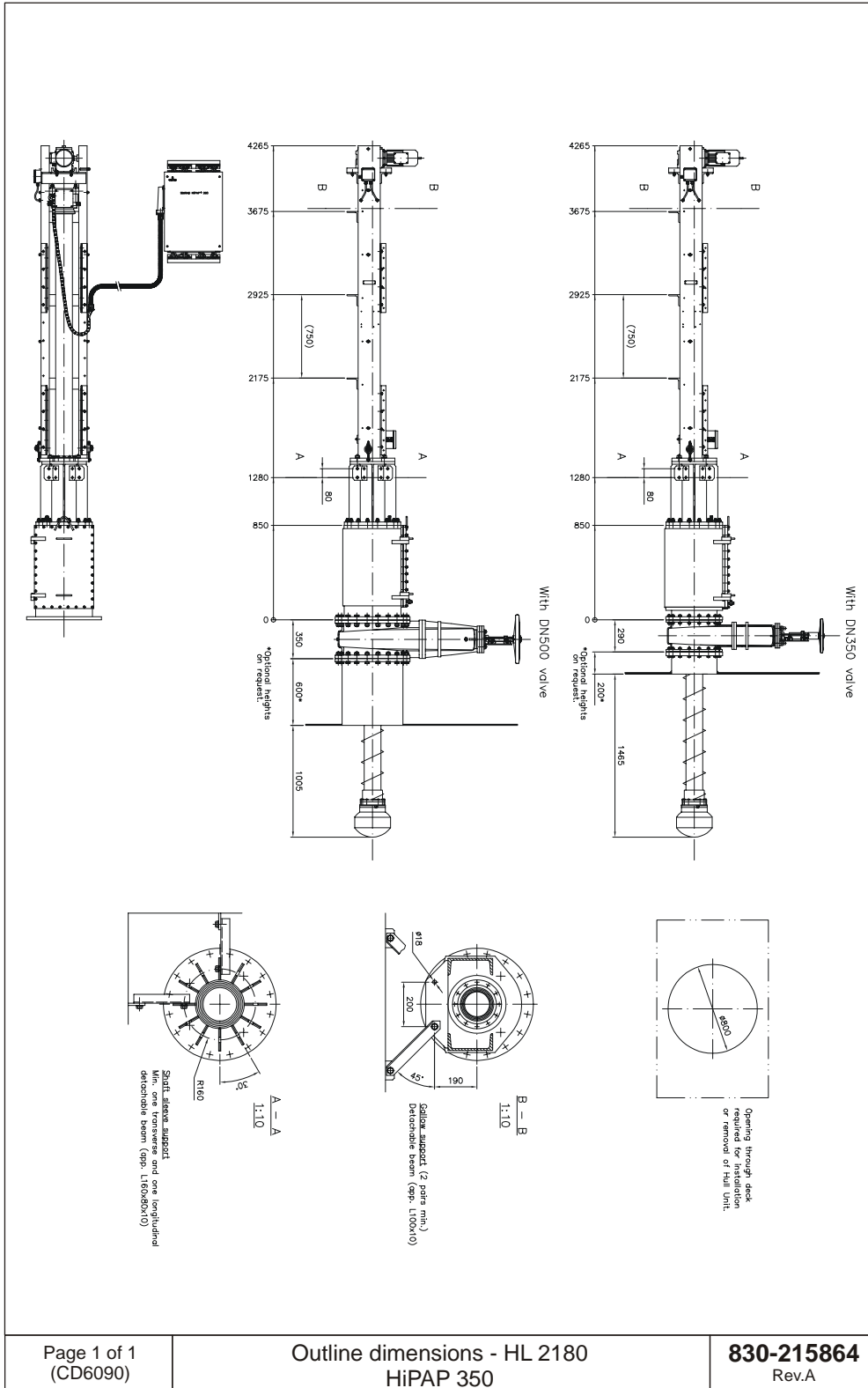
HiPAP 500 HL 4570



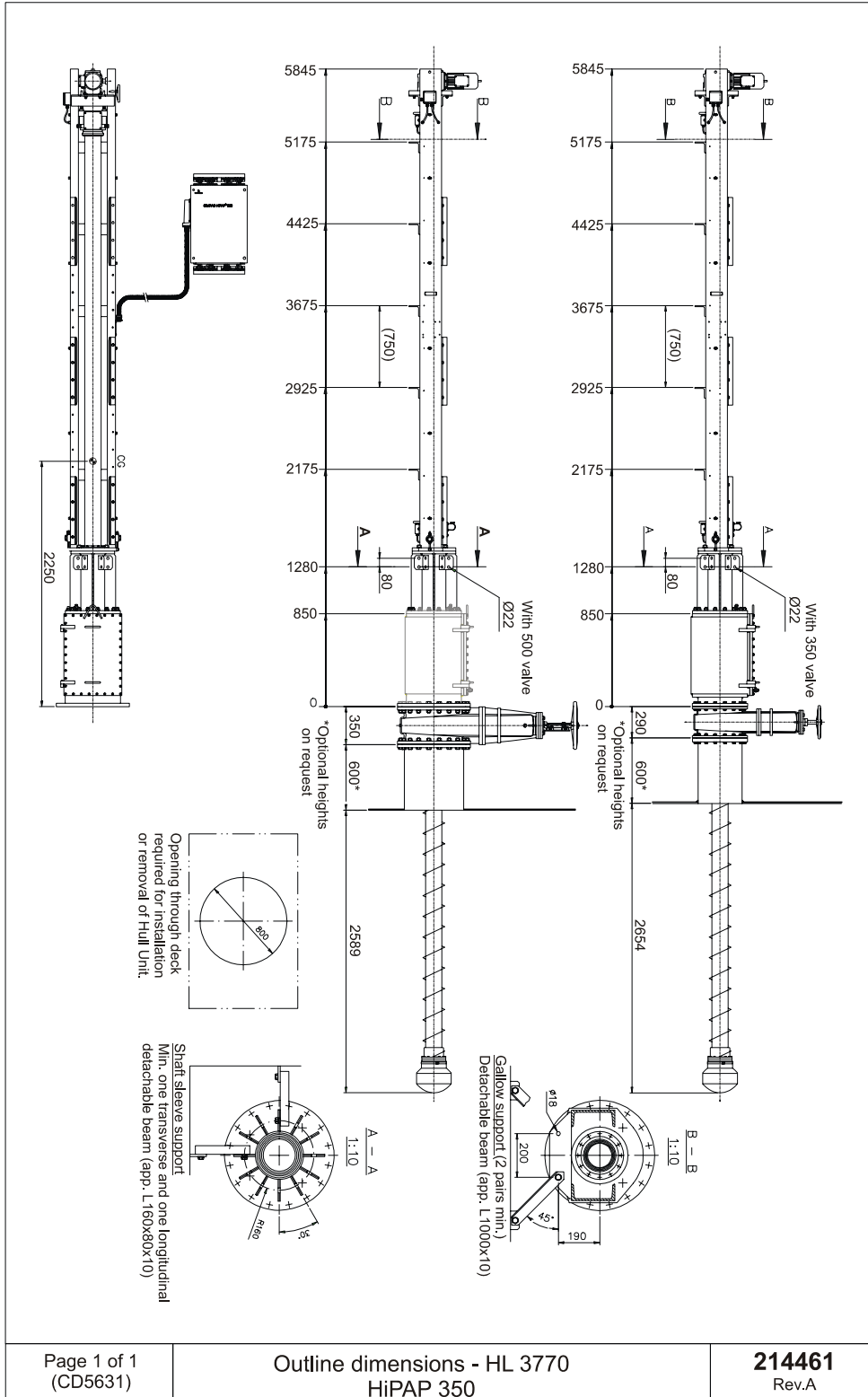
HiPAP 500 HL 6120



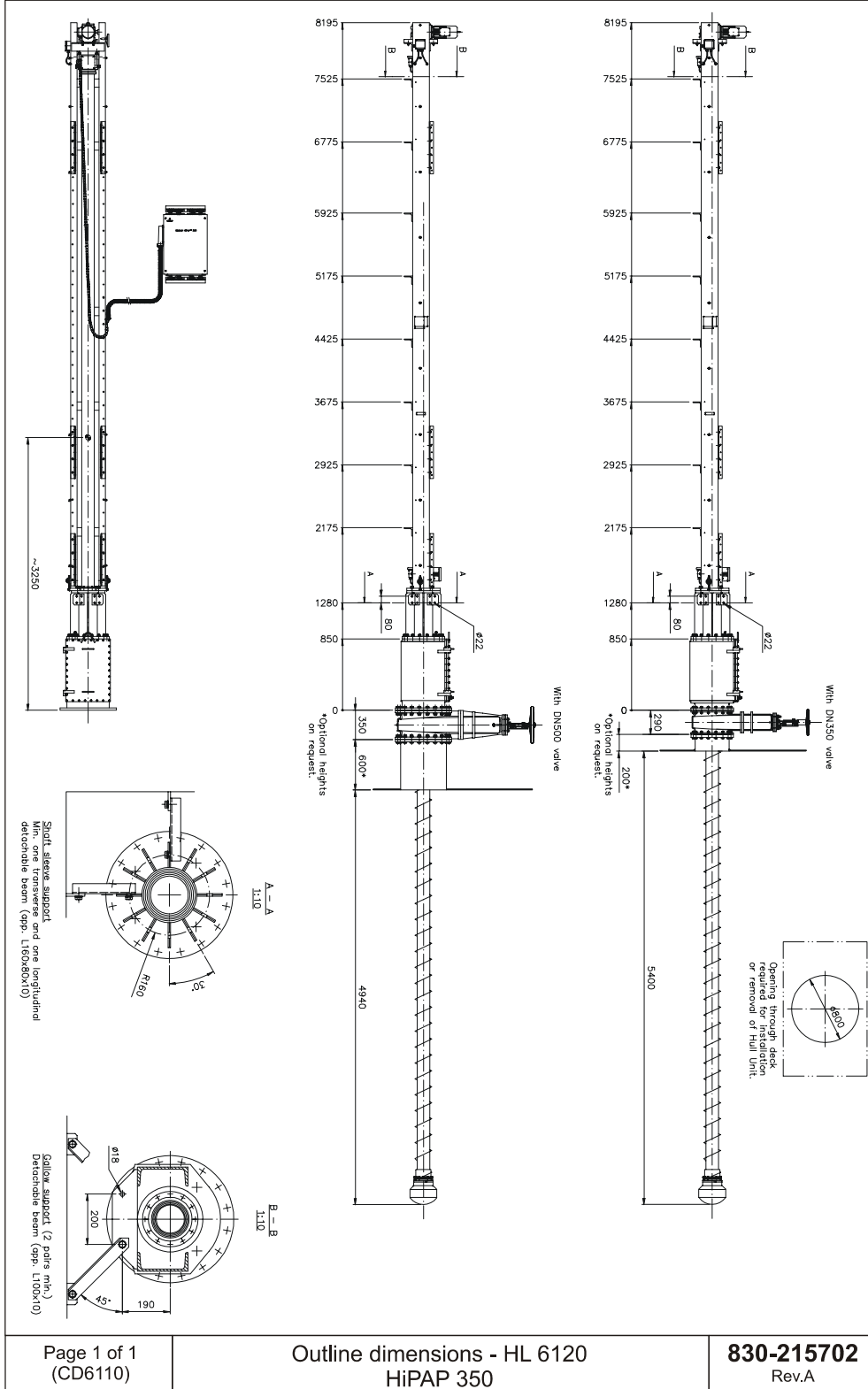
HiPAP 350 HL 2180



HiPAP 350 HL 3770



HiPAP 350 HL 6120



Page 1 of 1
(CD6110)

Outline dimensions - HL 6120
HiPAP 350

830-215702
Rev.A

