IMTMA -ACEMICROMATIC
PRODUCTIVITY CHAMPIONSHIP AWARDS -2022
EXPORT MANUFACTURING SBU

1. Brief Description of the project:

Scope: Manufacture, supply and installation of ICU grade Ventilators.
Objective: Production of 30000 Nos. of ICU Ventilators progressively within 3 months.
COVID spread in INDIA from March 2020 necessitating requirement of large no of ICU grade Ventilators to provide respiratory support to patients hospitalized.

Challenges faced while executing the project:

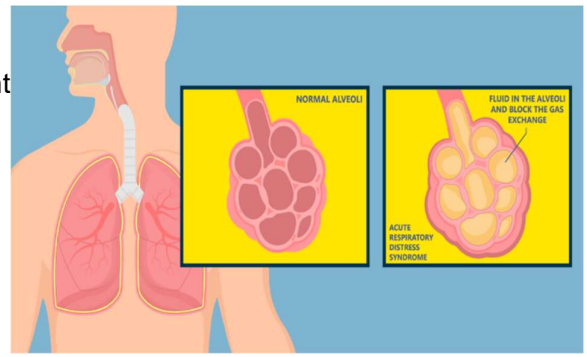
- BEL entering into manufacturing of critical care medical equipment for first time without prior experience, domain knowledge and infrastructure.
- Import Procurement of components from OEMs due to export restrictions and overseas domestic demand.
- Dynamic pricing and uncertain lead time.
- Timeline of delivery is very challenging.
- Subcontracting of work packages from MSMEs due to the nation-wide lockdown.
- Logistics issues due to cross border traffic closure, etc.
- Concurrent production model adopted as CV200 Ventilator newly launched.
- Clinical validation and approval to be obtained at AIIMS-Delhi in a short span of time.
- Certification : ISO 13485:2016 for Ventilator manufacturing
- TUV Certification for CV200 Ventilator

2. Trigger of the Project:

Background:
World Health Organization announced COVID19 disease as pandemic on 11th March 2020 and there were 1, 18,000 cases of the disease reported in 114 countries. The no of cases was increasing exponentially and the situation in INDIA was no different

KEY CONCERN:

- Potential for exponential growth of the numbers of patients
- Possibility of health care infrastructure being overwhelmed



COVID19 patients can experience Acute Respiratory Distress Syndrome (ARDS), a condition wherein a patient has extremely difficult breathing due to fluid collection in the lungs.
A patient with ARDS can be treated with mechanical ventilation, the goal of which is to provide oxygen to the patient while underlying disease runs its course.

Society of Critical Care Medicine and American Association for Respiratory Care (AARC) recommended Ventilation of COVID19 patients. When a patient requires Ventilator and one is not available, patient's life is at risk.

Govt. of India Initiatives:-

- Recovery Centres were planned to overcome challenges due to impending onset of pandemic affecting all citizen across social-economic strata. However recovery centres were not equipped with necessary Ventilators.
- Nearly 47.5K Ventilators only were available including public and private hospital across India against anticipated requirement of more than 100K units.
- GOI under PMCARES fund rolled out a plan to procure additional 50K units of Ventilators in a span of 3 to 4 Months.
- GOI directed BEL to submit feasibility report of mass manufacturing of ICU grade ventilators for combating the COVID-19 pandemic.
- The CV-200 ICU Ventilator, for which BEL has obtained the manufacturing ToT from private partner. The product had to be customized to add some of the features that are essential for treatment of COVID symptoms.
- BEL received an order for manufacture, supply and commissioning of 30,000no's of Ventilators within a period of 3 months.

Statistics of Ventilators availability in INDIA before pandemic

Ventilators in States/UTs

India Total	Number of ventilators in public sector	Number of ventilators in private sector	Total number of ventilators (public + private)
	17,850	29,631	47,481

	States/UTs	Number of ventilators in public sector	Number of ventilators in private sector	Total number of ventilators (public + private)
1	Lakshadweep	8	3	11
2	Dadra & Nagar Haveli	15	8	24
3	Daman And Diu	6	25	31
4	Andaman Nicobar Islands	27	5	32
5	Manipur	36	9	45
6	Sikkim	39	10	49
7	Mizoram	50	12	62
8	Nagaland	47	17	64
9	Arunachal Pradesh	60	6	66
10	Goa	75	39	115
11	Tripura	111	6	117
12	Puducherry	89	40	129
13	Meghalaya	111	20	131
14	Chandigarh	94	47	141
15	Jammu And Kashmir	182	18	200
16	Himachal Pradesh	310	91	401
17	Chhattisgarh	235	200	436
18	Uttarakhand	213	383	596
19	Assam	429	176	604
20	Odisha	463	178	641
21	Jharkhand	270	393	662
22	Bihar	292	480	771
23	Haryana	281	623	904
24	Delhi	610	377	986
25	Punjab	448	1,077	1,525
26	Gujarat	504	1,117	1,622
27	Madhya Pradesh	778	846	1,623
28	Andhra Pradesh	578	1,502	2,081
29	Rajasthan	1,176	1,153	2,329
30	Kerala	950	1,531	2,481
31	Telangana	525	1,973	2,498
32	West Bengal	1,964	874	2,838
33	Tamil Nadu	1,938	1,946	3,884
34	Maharashtra	1,286	4,507	5,793
35	Karnataka	1,743	4,810	6,553
36	Uttar Pradesh	1,907	5,129	7,035
37	Ladakh	NA	NA	NA

CDDEP The Center for Disease Dynamics, Economics & Policy

Numbers of ventilators (both in public and private sectors), are estimated values
States/UTs have been arranged in increasing order of total number of ventilators

PRINCETON UNIVERSITY

3.Solution generation, Innovation and Complexity.

A. Creation of War Room.
   - Complete project (30000 Nos. Ventilators) is required to be completed within a span of 3 to 4 months' time.
   - All the required coordination from D&E, ToT Partner, Purchase, Production, marketing is necessary without any delay.
   - Movement of man was restricted by GoI and GoK due to lockdown declared. Hence it was required to bring various departments in the same work place.
   - To enhance the team work and faster resolution of challenges War Room was created for faster decision making.

B. Formation of empowered teams for various functions.
   - In order to meet the project timeline, It was necessary to reduce the procurement cycle time to less than 3 days.
   - Since BEL is manufacturing Ventilators for first time, it is required to understand the assembly, testing, QA in a quick span of time.
   - Complete required infrastructure for manufacture of Ventilators was required to be set up within a month to start the production.

- Hence teams for various functions like Procurement, D&E, Assembly, Marketing, Infrastructure planning was made. These teams were headed by a General Manager.

C. Optimum utilization of Assets:
- Scarcity and non-availability of required resources due to stringent project timeline and lockdown.
- Involving the engineers working from home for coordinating and follow-up activities.
- Set up of multiple production lines to meet the production Takt time.

D. Addressing of Critical and long lead parts:
- Identify the critical and long lead time parts in the BOM.
- Find the alternate vendor, In-house production of critical items.
- Order on multiple vendors to address long lead time.
- Indigenization of imported long lead parts.

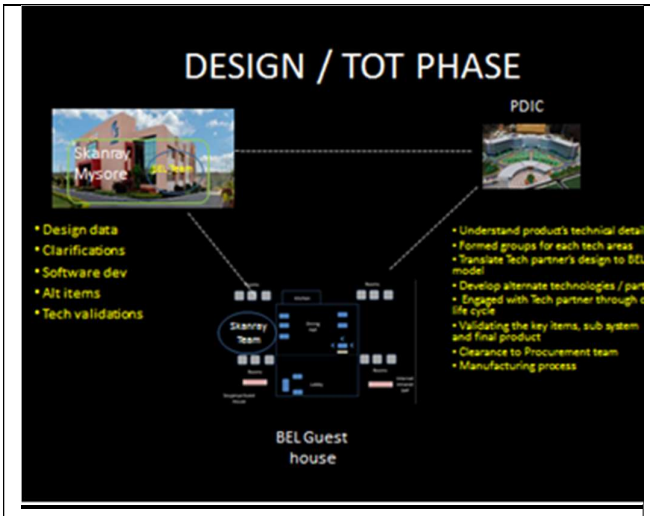
E. Supporting vendors to establish efficient supply chain:
- Facilitate the vendors to obtain the required permits for operation during pandemic.
- Support the vendors to source the raw material.
- Provide support for logistics, D&E, share the manufacturing and testing facility of BEL.
- Extending financial support to MSME vendors by providing advances and better payment terms.

4. Implementation.

Solutions selected were implemented:

A) Challenges and Risks:

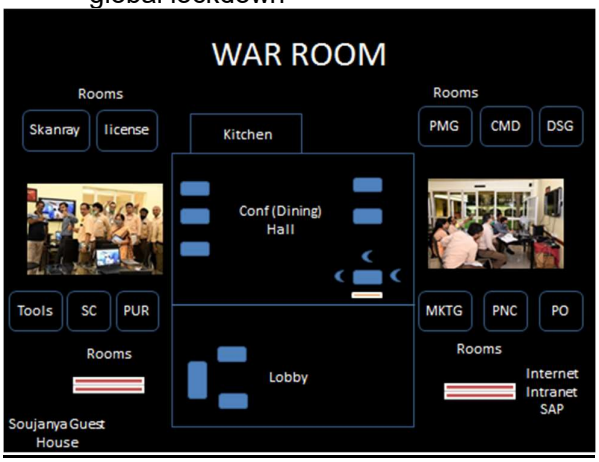
Challenges/Risk	Actions /Risk Mitigation
1. Entire world lock down. a. Factories not Operational b. Logistics not functional c. Requirement of Additional Work Force.	a) In view of pandemic situation, special permissions were taken from GOI & GOK by BEL for Opening the factories. Separate team involving HR,BEL Security was formed to coordinate and issue necessary permits. b) Special permission granted to Transport operators enabling them to move the materials for BEL and Tier I& Tier II vendors. Service of Other Units of BEL like Hyderabad, Mumbai, Ghaziabad, and Panchkula utilized for movement of the materials. c) Man power hired for carrying out the production activities of Ventilator.
2. a. Concurrent production model adopted. b. BEL location Bangalore-TOT partner located in Mysore	a) D&E Engineers from BEL and ToT Partner were made available round the clock for design documentation and assisting Procurement team. b) i) Co-Location of BEL design team and ToT Partner team at both locations(Bengaluru and Mysore) enabled effective and efficient communication in real time for design enhancement. ii) BEL-Digicloud utilised as single window communication between BEL & ToT Partner.



c. BEL teething issues in establishing production line, Manufacturability issues etc..

c) ToT Partner production team was stationed in BEL to establish assembly line and guide the BEL production team.

3. a. Augmentation of Resources during global lockdown



b. Procurement Cycle time

c. Faster Managerial decisions.

a. Creation of War Room at BEL Guest houses.

All required resources like network connection, transport facility, canteen, security and all other infrastructure required for smooth working was set up within 2 days.

➢ Sanitization of work places at regular intervals and providing required PPE kits as recommended by Govt.

➢ Since all the resources were made available under one roof, decisions was taken up immediately and thereby reducing the cycle time.

b) i) Approach paper approval was obtained for ease of procurement Cycle time reduced to 3 days.
ii) New set up were made for D&E, Planning and procurement activities in one building.
c) Senior management of BEL was also stationed at WAR room for dynamic decision making and approvals.

d) i) During lock down BEL work force was working from home. Hence a follow-up team headed by General Manager was formed with a goal to address the vendor issues and to ensure on time delivery of materials.

ii) Electronic real-time dash board was created to monitor the status and progress of the project.

d. Monitoring of Project execution.	
4. Non availability of critical parts due to global demand/export restrictions. a. Indigenisation and Alternate part/Vendors b. Multiple Vendors for same parts(Mechanical)	a. BEL with the support of DRDO and ToT partner identified the alternate suppliers for the following parts. They were funded by BEL to fast track the development process. i. Solenoid Valves: Uflow, Godrej Aerospace, Nucon Aerospace, Chakradhara Aerospace, BEL Components-SBU, Asco Emerson. ii. Pressure Regulators: IMI, Janatics. iii. Pressure Sensors: Act Sensors, Merit Sensors. iv. Pneumatic fittings: Festo, IMI, Metal works, Asco Emerson, Janatics. v. Hose connectors & Pipe: The Aerospace Engineers. b. Long lead Mechanical part-Manifold Inspiration-13 Vendors established to receive the material in-time at BEL to meet the production requirements, resulting in increased productivity.
5. More than 100 vendors, coordination required with vendors for on time delivery of parts and to address any issues.	A. Each Engineer was assigned with set vendors and task to ensure receipt of material at BEL. This reduced the lead time of material receipt by more than 50%, resulting improved productivity. b. BEL Engineers were stationed at critical suppliers for follow-up and dispatch of critical parts.
6. Import Logistics	1. Customs clearance at Delhi, Mumbai, Bangalore and Chennai based on the early flight availability and queue in customs. 2. Advance BOE filing for faster customs clearance.
7. Non availability of VT-650 Gas flow analysers.	Lead time of procurement of VT-650 was more than 45days. Hence to ensure continuous Testing of the items, Gas flower analysers were hired/rented from Service providers (M/s TBS) for period of 60 days.
8. Management of BEL work force during ventilator production	To ensure safety of employees and having continuous production, staggered shift timings introduced with 6 different timings.
9. Capacity constraints and non-availability adequate resources in EM SBU. 	Realignment of Manufacturing Facility to meet production of medical grade ICU Ventilator in lieu of defence products 1.Production was carried out in 6 SBU's for higher production and optimum utilization of resources. • Ventilator Production: Export manufacturing, Military Communication and T&B's SBU. • Compressor Production: Missile Systems SBU. • Blender Assembly : T&B's SBU. • Trolley and Accessories : EWA SBU • Packing and Dispatch : PDIC 2. Apart from above workforce from SBUs not involved in Ventilator projects were posted in the different SBUs

	for Ventilator production, ensuring man power availability. 3. A task team was formed with Engineers from Material management to coordinate with all the SBUs and to ensure on time material receipt at the various production locations. 4. Infrastructure to manufacture Ventilator established afresh on war-footing. • Within two weeks' time, laid 3-km-long copper tubing. • Ultrasonic cleaning bath. • Created facilities for 1,000 cubic metre oxygen and 500 CFM pure air per day.
Cycle time of Production -Requirement was 300 Nos/Day.	• Process improvement through Suggestions - 40 • Productivity improvements through QCC - 10 • With above an output was increased to 380 Nos/day from 140/day.

5. Results and Impact:

1. Manufacturing of 30,000nos of Ventilators were completed in a record time of 3months
2. Manufacturing of Ventilator has increased turnover of BEL by additional 1200 Crs.
3. Additional order for manufacturing of 2000 nos of Ventilator from GMSCL,Gujarat in year 2021-22 and executed successfully.
4. The experiences in manufacturing of ventilators lead to formation of separate business vertical for Medical equipment.
5. Boosted Confidence in manufacturing other Medical devices like Oxygen concentrator, Hemodialysis Machine and Patient Monitoring System to name a few.
6. Govt. of India entrusted BEL and placed order for manufacturing of 17,000 no's of Oxygen Concentrator and executed successfully in the year 2021-22.
7. Contract manufacturing of SPOC controller board for Bharat Forge Limited.
8. Indigenization of components which were sourced from other countries.
9. Delegates from South African countries visited BEL and found potential opportunity to export the medical products.

Mandatory parameters:	Before	After	Unit of Measurement
1. Market share	0	65	% of Ventilators deployed during COVID
2. Productivity	140	Upto 800	units/day
3. Direct Cost	Reduced by 10%		% of Selling price
4. Delivery	-	30000	In 90 days
5. Training Session	0	9595	No of newly trained users
6. Alternate sources	0	35	No of vendors
7. Indigenisation	60	75	% of BOM
8. Man hours	14	6.3	Hours/Unit
9. Procurement Cycle time	30	3	No of days
Parameters in the table are as applicable in context of this project.			

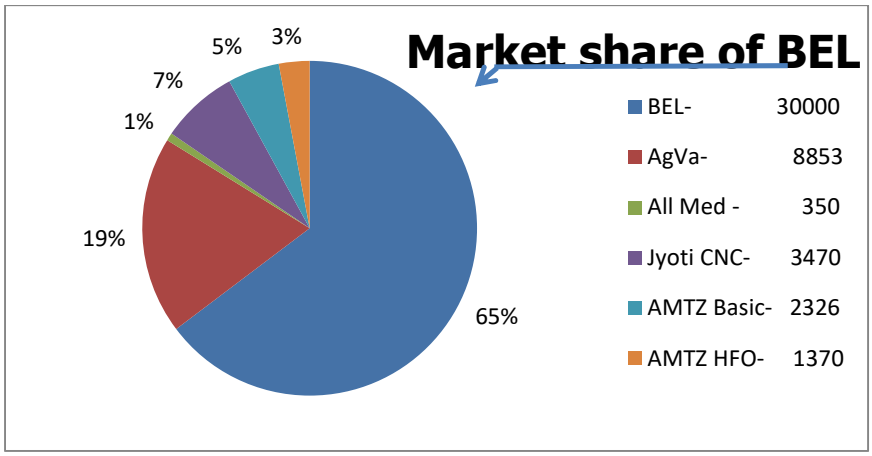
6. Resource Impact:

A. Precious human life saved across the country.
B. Healthcare infrastructure enhanced in the society.
C. Existing Defence manufacturing infrastructure effectively converted to health care manufacturing facility without huge investment.
D. Online training sessions on ventilator usage was arranged by BEL for the period of 18 Months for healthcare professionals, thus enhancing their competency.
E. Indigenisation of critical parts has FE savings and has created employment opportunity.

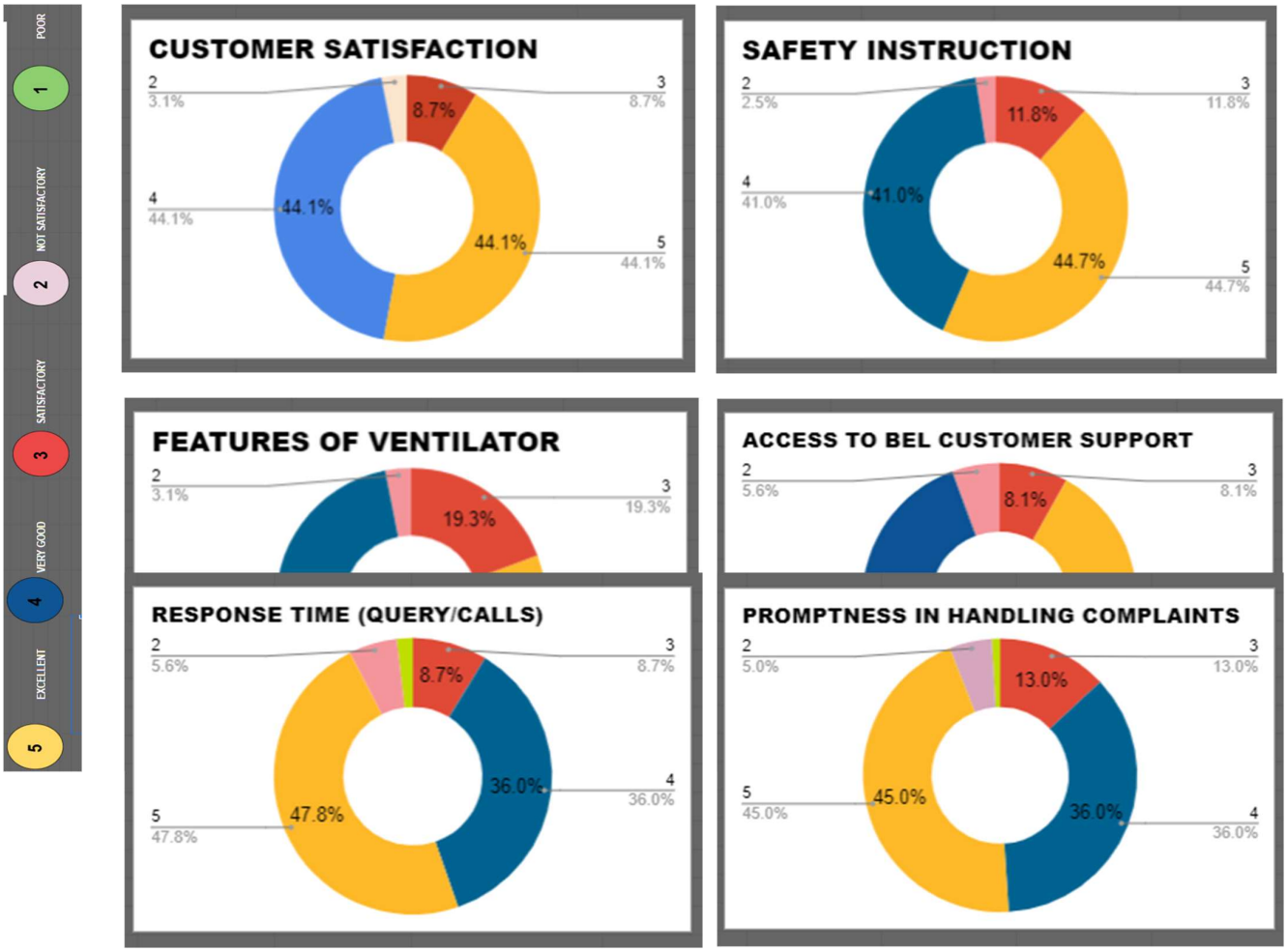
F. Enhanced the knowledge and competency in manufacturing of the healthcare components of Indian suppliers.
G. This had provided thrust towards Atma Nirbhar Bharat in healthcare equipment's.
H. Established India as a Major Hub for Ventilator manufacturing.
I. Established Customer support Cell for 24X7 assistance to hospital staff.

7. Business Metrics:

Market share of BEL for Ventilators supplied during COVID-19 under PMCARES initiative.



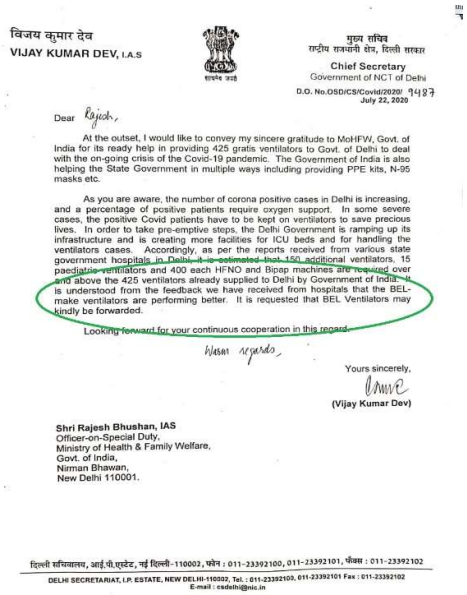
CUSTOMER RATINGS FOR BEL Ventilators



8. Recognistions:

a. ***"Best CEO industrials award"*** for CMD of BEL by Business Today Magazine (BT-PwC).
b. ***"Platinum Award***" By CII on ***"Outstanding managers competition"*** manufacturing such huge Quantity within given period of time during Pandemic.
c. ***Award*** by "***ITP Media***" as ***"Manufacturing company of the year"***.
d. Appreciation letters by customers.
e. Individual Appreciation Certificates issued by SBU heads.

Appreciation by Chief Secretary of Delhi:



विजय कुमार देव
VIJAY KUMAR DEV, I.A.S

मुख्य सचिव
राष्ट्रीय राजधानी क्षेत्र, दिल्ली सरकार
Chief Secretary
Government of NCT of Delhi
D.O. No.OSD/CS/Covid/2020/ 9487
July 22, 2020

Dear Rajesh,

At the outset, I would like to convey my sincere gratitude to MoHFW, Govt. of India for its ready help in providing 425 gratis ventilators to Govt. of Delhi to deal with the on-going crisis of the Covid-19 pandemic. The Government of India is also helping the State Government in multiple ways including providing PPE kits, N-95 masks etc.

As you are aware, the number of corona positive cases in Delhi is increasing, and a percentage of positive patients require oxygen support. In some severe cases, the positive Covid patients have to be kept on ventilators to save precious lives. In order to take pre-emptive steps, the Delhi Government is ramping up its infrastructure and is creating more facilities for ICU beds and for handling the ventilators cases. Accordingly, as per the reports received from various state government hospitals in Delhi, it is estimated that 150 additional ventilators, 15 paediatric ventilators and 400 each HFNO and Bipap machines are required over and above the 425 ventilators already supplied to Delhi by Government of India. It is understood from the feedback we have received from hospitals that the BEL-make ventilators are performing better. It is requested that BEL Ventilators may kindly be forwarded.

Looking forward for your continuous cooperation in this regard.

Warm regards,

Yours sincerely,

(Vijay Kumar Dev)

Shri Rajesh Bhushan, IAS
Officer-on-Special Duty,
Ministry of Health & Family Welfare,
Govt. of India,
Nirman Bhawan,
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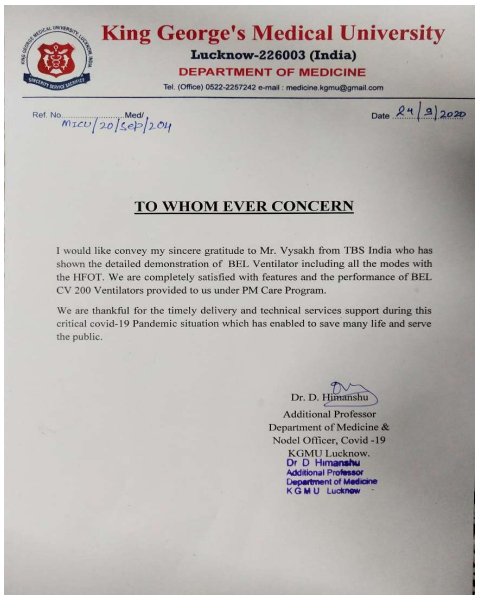
E-mail : csdelhi@nic.in

Appreciation by Hospital:



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Ref. No. MICU/20/SEP/2.014 Date 24/9/2020

TO WHOM EVER CONCERN

I would like convey my sincere gratitude to Mr. Vysakh from TBS India who has shown the detailed demonstration of BEL Ventilator including all the modes with the HFOT. We are completely satisfied with features and the performance of BEL CV 200 Ventilators provided to us under PM Care Program.

We are thankful for the timely delivery and technical services support during this critical covid-19 Pandemic situation which has enabled to save many life and serve the public.

Dr. D. Himanshu
Additional Professor
Department of Medicine &
Nodel Officer, Covid -19
KGMU Lucknow.
Dr D Himanshu
Additional Professor
Department of Medicine
K G M U Lucknow

9. Scope for horizontal deployment:

- ✓ Emergency procurement procedure for critical projects in line with Ventilator approach paper is being implemented across the organisation Ex: Oxygen Concentrator.
- ✓ Digital Dash board monitoring system deployed for other projects
- ✓ Follow up team concept being used for across the Organisation for emergency projects.
- ✓ Job outsourcing of assemblies concept deployed for other projects.
- ✓ Packing outsourcing concept also introduced for other projects.
- ✓ Expertise in solenoid valve manufacturing which can be used for the other projects.
- ✓ ISO 13485:2016 certification for ventilator manufacturing, enhanced confidence to obtain any medical equipment certification in future.