ТИТИ CONSULTING ENGINEERS LIMITED
ENGINEERING A BETTER TOMORROW
OVER FIVE DECADES

TCE Emergency Response for
Gaseous Oxygen Storage and Distribution

First Version released 20 ${ }^{\text {th }}$ April 2021

T^TA CONSULTING ENGINEERS LIMITED
ENGINEERING A BETTER TOMORROW
over five decades


This presentation is an abridged version and must be read after having read the detailed White paper :
https://www.tce.co.in/wp-content/uploads/2021/04/Meeting-Oxygen-Demand-Tata-Consulting-Engineers-Response.pdf

## WE MUST COME TOGETHER AND HELP WITH HOPE AND POSITIVITY

## Covid Aid 2020 Efforts:

Engineering Consultancy by Tata Consulting Engineers (TCE)
COVID MODULAR Hospitals


## COVID 2021 Second Wave - Medical Oxygen - Challenges Faced



Other Options - Exhausted



Centralized Cryogenic GenerationDistribution is Bottleneck
Inadequate In situ Generation at Hospitals



FOR IMPORTING NEW UNITS

Alternate and out of box solutions for Oxygen GENERATION and DISTRIBUTION is Crucial

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## Covid Aid 2021 Efforts:

## CLICK for DETAILS

## PSAN2O2 \& PSAO2

Innovative open source solution for Plant scale
Oxygen generation

1. Conceptualised an innovative idea and engineered the conversion of existing PSA Nitrogen plants to PSA Oxygen plants
2. Implemented successful pilot with IIT Bombay in 03 days
3. Partnered with Tata Chemical for required sourcing of Zeolite from Europe
4. With the support of Min of Commerce, PSA, DSIR \& CSIR received GOI - IAF support for urgent airlifting of a critical resource for the conversion
5. Ongoing program under Min of Environment, CPCB, TCE is project managing feasibility of more than $150+$ plant ( 80,000 LPM) conversion across India, with 65 confirmed plants ( 35,000 LPM) as on date
6. and providing technical expertise, design guidance and consulting to 1500+ teams across India in their endeavour to solve the oxygen crisis, Technical Specs, zeolite procurement \& assistance for NEW oxygen plants

## This Presentation

## C2O

Solutions for effective
Oxygen supply chain

1. by proposing an innovative solution of using existing cylinders ( $\mathrm{LPG} / \mathrm{CO}_{2}$ ) for Oxygen distribution
2. by leveraging the existing supply chain of LPG / CNG for Oxygen supply across the country


## CLICK for DETAILS

## O2C

Solution for portable Oxygen generation

1. Supporting MSME across India for mass manufacture of Oxygen Concentrators
2. Working prototype of Portable Oxygen Concentrator with an open-source design created in 05 days
3. $100 \%$ indigenous concentrator supporting India's Atmanirbhar Vision
4. Prototype produces 20 LPM @ 94\% oxygen purity

Consulting on Oxygen Generation supply chain and capacity enhancement

1. across various States, namely Rajasthan, Maharashtra, Uttar Pradesh, Odisha, Andhra Pradesh, Silvassa, Gujarat
2. to NGOs, hospitals including Tata Medical Centre for their Oxygen augmentation and readiness
3. Emergency Modular Units with Oxygen, AC and Medical support

## Emergency Oxygen Storage and Distribution: Ongoing Efforts

## Involved Authorities

TИTИ


## THESE CONVERSIONS CAN ONLY BE DONE BY GOVERNMENT AUTHORITIES.

All these methods INVOLVE Statutory, Legal and other APPROVALS. Proper cleaning and COLOUR coding of CYLINDERS is required for SAFETY reasons. A governance mechanism involving government officials, PESO, Controller of Explosives, Fire Department, Medical Department (Min. of Health) and administrative authorities is required for related compliances and approvals.

OUTCOME $\mathbf{= 8 0 0 0}$ MT of Oxygen Storage addition

1. 80 Lacs LPG Cylinders* (average 02600 litres /cylinder)
2. $\mathbf{7 2 0 0}$ MT
*India has ~40 Cr Household LPG Cylinders

This Conversion Program needs to be executed at a NATIONAL Scale to realize above numbers

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## What is Needed?

## CYLINDERS - Supply Chain for Distribution

## 1. Government approval and a Central GOVERNMENT BODY to take this forward

2. APPROVAL: PESO, CPCB and other approval and SOP - COLOUR coding - need to be painted, certification of cylinder and tamper proof identification / Sealing (post filing of Oxygen) + proper Quality testing and SAFE usage of OXYGEN filled
3. SAFETY: proper CYLINDER unique identifier and naming convention - to ensure authentication of the lot using simple SMS - and track and trace
4. VOLUME Possible: Nitrogen, Argon, and other cylinders already in use - we are aiming to use CO2 Cylinders, CNG and LPG Cylinders are 40-50 Cr in numbers - we can use approx. min 10\% of these - LAST MILE CONNECTIVITY / DISTRIBUTION beyond LOX Tankers / Other Containers
5. Leverage existing LPG bottling plant (SPARK-Resistant compressors, and well-established LPG distribution network for last mile connectivity across India.
6. ABOVE as emergency solution after exhausting options of Oxygen and currently approved Nitrogen and INERT gas industrial cylinders

## LPG Cylinder Conversion - SAFETY / Tracking / Audit

SAFETY: CONVERSION with proper COLOURING - CYLINDER unique identifier and naming convention - to ensure authentication of the lot using simple SMS - and track and trace


## Why LPG cylinders?

1. India has approx. 40 Cr LPG Cylinders $-2 \%$ ie 80 lacs of LPG Cylinders may be converted
2. 80 Lac LPG Cylinders will enable storage and transportation of 7000 MT of Oxygen
3. LPG Cylinders will be at max 20 BAR - no complex air compressor required for 150-200 bar capacity can also be done with manual compressor
4. Stores upto 640 litres of oxygen in a LPG Cylinder
5. Existing LPG bottling plants across the country may be used
6. Simple conversion - no changes needed except cleaning
7. Use same LPG regulator - and connect to OXYGEN low pressure line at 1.2 BAR
8. Use NRB Masks and NOT CANNULA for ensuring Oxygen at higher concentration and NO to ZERO oxygen wastage
9. It is recommended that LPG Cylinder to be used ONLY as a CYLINDER BANK and with ONLY NRB masks and NOT CANNULA
10. Human intake is max 0.5-1 LPM - except ventilator that forces higher oxygen - for patients who are not critical and hence not on VENTILATOR - LPG cylinder oxygen can be used
11. LPG Cylinder to use regulator with output at 1.2 BAR - and max 5 LPM - and with NRB Mask
12. Also use this setup with LPG cylinders for HOSPITALS that don't have existing oxygen line (which is at 4.5 bar for ventilator)

## National Program using Converted LPG cylinders

1. This Program has to be done on NATIONAL Scale - with aim for 80 Lac LPG Cylinder Conversion for their use at HOSPITALS that do not have existing Oxygen supply and for Patients who are not Critical and needing between 1-5 LPM Oxygen only.
2. Railways network for transportation may be explored for both cylinder and modular unit transportation and the cylinders and units are to be unloaded at various stations across India. Cylinders are continuously replenished every 12-24 hours - this is one of the possible mechanism to provide Oxygen across India
3. Also via road we use the existing LPG distribution network of OIL Marketing company to provide these Oxygen filled LPG Cylinders across Cities/ Villages
4. Modular container Covid units - with 5 beds - AC and provision for oxygen cylinders OR converted CNG / LPG cylinders outside this with oxygen line connectivity provided
5. Number of cylinders to put outside this can be 20-30-40-60 etc such that 50\% are connected and 50\% ready for change over

## $\mathrm{CO}_{2}$ Fire Extinguisher Cylinders for Storage of Oxygen

| $\mathrm{CO}_{2}$ <br> Extinguisher <br> Capacity (kg) | Min. <br> Residence <br> Time (Hrs) | Max. <br> Residence <br> Time (Hrs) |
| :---: | :---: | :---: |
| 2 | 1.3 | 2.7 |
| 3 | 2.1 | 4.2 |
| 4.5 | 2.7 | 5.5 |



संख्या: D-21013/PBL/18-Exp


CIRCULAR
Sub: Standard Operating Procedures (SOP) for conversion of Industrial Oxygen Cylinders and n. Argo \& Helium only) to Medical Oxygen Cylinders in the nert Gas Cyinders
wake of COVID-19 pandemic- reg.
$\mathrm{CO}_{2}$ fire extinguisher cylinders are suitable for medical oxygen w.r.t construction and Mechanical Integrity

## - Bank of multiple cylinders

 for high flow requirements$\mathrm{O}_{2}$ supply to patients $-5 \mathrm{It} / \mathrm{min}$ and 101t/min

PESO Guidance Can Be Suitably Used For Conversion

[^0]Plenty of Fire extinguisher are already available across - both under new production, or under usage at many locations, offices, Theatres, malls, etc.

## LPG Cylinders for Storage of Medical Oxygen



1. LPG cylinders are widely available ( $\sim 28.13 \mathrm{Cr}$ connections)
2. New / unused cylinder is preferred to avoid possibility of contamination
3. Used cylinders during emergency Inertization (solvent-based cleaning), Purging with Nitrogen/air and drying is necessary

Low Pressure Storage Lower Residence Time.

| Capacity | Min Res <br> time (hr) | Max Res <br> time (hr) |
| :--- | :---: | :---: |
| 1 Domestic <br> Cylinder | 1.1 | 2.1 |

Basic Materials Of
Construction are Suitable for Oxygen Service


## $\mathrm{O}_{2}$ supply to patients - $5 \mathrm{It} / \mathrm{min}$ and $101 \mathrm{t} / \mathrm{min}$

TATA


For requirement of higher oxygen, a bank of 10-50 cylinders may be used.

## CNG Cylinders for Storage of Medical Oxygen



## Conversion Procedure

- Cleaning And Inertization
- Inspection
- Corrosion Checks
- Nozzle Replacement
- Hydrotest, Drying
- Painting
- Certification and Approvals

| INTERNATIONAL | ISO |
| :---: | :---: |
| STANDARD | 11621 |
|  |  |

Gas cylinders - Procedures for change of gas service


Painting



Nozzle
Replacement

## LPG Cylinder Bank

## For details - Please use this LINK:

## LPG Cylinder White Paper

## Bill of Quantities for Cylinder Bank



| Sr. No. | Item Description | Specification | Name of Suppliers |
| :---: | :---: | :---: | :---: |
| 1. | LPG Cylinders | Domestic LPG Cylinder of 14.2 kg storage | HPCL/BPCL/IOCL |
| 2. | Manifold till regulator | 25NB (1") conforming to ASTM A-312 TP304. | United/Greentech |
| 3. | Adaptor | Body - Pressure die-cast from zinc alloy. Brass parts shall be from free cutting brass bar. Rubber components from nitrile rubber conforming to IS 9798. | United, SKN, Vanaz, Nova Comet, Medas Gas |
| 4. | Flexible Wire-Braided Cylinder Pigtail | Rubber tube - Synthetic \& acryl nitrate butadiene rubber and compatible to Oxygen. <br> Brass nuts - Forged from wrought or extruded sections. | Markwell, United |
| 5. | Non-Return Valve (NRV) | Body - Bronze, Disc - Bronze | SKN, United, leader |
| 6. | Pressure Gauge with isolation valves | Dial - 4", Pressure Range - 0 to 10 bar(g) | Donfoss, Alot, |
| 7. | Manifold Isolation Ball Valve | Body - Cast Steel | Audco, Leader, Hawa |
| 8. | Automatic Changeover Valve with Adjustable Regulator | Outlet pressure is adjustable between $0.5 \operatorname{bar}(\mathrm{~g})$ to $1 \operatorname{bar}(\mathrm{~g})$. The flow rate is between 20 to $50 \mathrm{~kg} / \mathrm{hr}$. Body \& cover is made from die cast zinc alloy. Diaphragm \& valve pad from synthetic nitrile rubber conforming to IS:9798 | United, SKN, Vanaz, Nova Comet, Medas Gas |
| 9. | ACF, Fine filter \& Sterile Filter | 304 stainless steel construction, 0.01 micron filtration, Organisms, oil, dirt with efficiency in access of 99.99\% | Walker. Parker |
| 10. | Gas Meter | Conform to BS 4161 Part 5. Maximum outlet pressure is $0.1 \operatorname{bar}(\mathrm{~g})$. Normal working pressure range is 0.020 to $0.05 \operatorname{bar}(\mathrm{~g})$. Max gas flow rate is $2.5 \mathrm{Nm}^{3} / \mathrm{hr}$ Minimum rate is $0.016 \mathrm{Nm}^{3} / \mathrm{hr}$. | Raychem RPG / ITRON |

## Things to READ and Keep in Mind

## Considerations for oxygen use

## For management of COVID-19 ${ }^{\text {Version 5.3] }}$

This guide is for staff in charge of patients who are on oxygen therapy. This is not a replacement for in-depth training but to be used as a quick reference guide. Combine with prone positioning as tolerated.


Simple face mask (5-10L/min)
 the head.

Reservoir mask
(up to $15 \mathrm{~L} / \mathrm{min}$ )


## Reservoir mask



WITH Converted LPG Cylinders for Oxygen Storage : ONLY Reservoir Storage: ONLY Reservoir
Mask to be used with max 5 LPM and regulator pressure of 1.2 barg


## Illustrative Image: Use of Modular Units along with Oxygen Cylinders



Reservoir mask


WITH Converted LPG Cylinders for Oxygen Storage: ONLY Reservoir Mask to be used with max 5 LPM and regulator pressure of 1.2 barg

Illustrative Image: Use of Modular Units along with Oxygen Cylinders


Reservoir mask


WITH Converted LPG Cylinders for Oxygen Storage : ONLY Reservoir Mask to be used with max 5 LPM and regulator pressure of 1.2 barg

Illustrative Image: Use of Modular Units along with Oxygen Cylinders


Illustrative Image: Use of Modular Units along with Oxygen Cylinders


Reservoir mask


WITH Converted LPG Cylinders for Oxygen Storage : ONLY Reservoir Mask to be used with max 5 LPM and regulator pressure of 1.2 barg

## Illustrative Image: Use of Modular Units at Railway Stations



Illustrative Image: Use of Modular Units at PLAYGROUNDs


## LPG Cylinder Calculations

| LPG Cylinder for Oxygen |  |  | Converted Cylinders - Distribution Potential |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Temp. of $\mathrm{O}_{2}$ cylinder filling | ${ }^{0} \mathrm{C}$ | 30 | Oxygen Supply Rate | *LPM | 5 |
|  |  |  | Residence Time in One Cylinder | min | 121.5 |
| Cylinder Pressure | $\mathrm{kg} / \mathrm{cm}^{2} \mathrm{a}$ | 21 |  | hr | 2.0 |
| Supply Pressure - Outlet | $\mathrm{kg} / \mathrm{cm}^{2} \mathrm{a}$ | 1.2 | Number of Cylinders required for SINGLE |  |  |
| Supply Temperature - Outlet | ${ }^{0} \mathrm{C}$ | 40 | Patient in 24 hours @*LPM |  |  |
|  |  | 40 | Qty. of $\mathrm{O}_{2}$ that per Day for a Patient @*LPM | kg/day | 10.5 |
| $\mathrm{O}_{2}$ Mass Stored in Pressurized Cylinder | kgs | 0.89 | $\mathrm{O}_{2}$ Qty. that 1 Lakh Cylinders Can Supply in a Day | MT/day | 89 |
| Volume of $\mathrm{O}_{2}$ available for supply at given outlet temp \& press | Ltr | 607 | Properties |  |  |
|  |  |  | Water Capacity of LPG Cylinder | Ltr ${ }^{3}$ | 33.6 0.0336 |
| LPG Cylinder Bank for Oxygen |  |  | Molecular Weight | $\mathrm{kg} / \mathrm{kg} \mathrm{mol}$ | 32 |
| No of cylinders in bank | No | 40 | Gas Constant, R | L.atm. $\mathrm{mol}^{-1}$. $\mathrm{K}^{-1}$ | 0.08205 |
| No of Patients being served by 1 bank (of 40 LPG Cylinder Bank) | No | 5 |  |  |  |
| Volumetric Capacity | Ltr | 24296 |  |  |  |
| Residence time of one Bank - for 5 Patients | hr | 16 |  |  |  |


| Oxygen Density Calculator |  |  |
| :--- | :---: | :---: |
| Temperaturt | ${ }^{\circ} \mathrm{C}$ | 20 |
| Pressure | $\mathrm{kg} / \mathrm{cm}^{2} \mathrm{a}$ | 21.033 |
| Density | $\mathrm{kg} / \mathrm{m}^{3}$ | 27.36 |

Please download excel for calculation

| Oxygen Density Tables |  |  |
| :---: | :---: | :---: |
| Temp. | Pressure | Density |
| ${ }^{0} \mathrm{C}$ | $\mathrm{kg} / \mathrm{cm}^{2} \mathrm{a}$ | $\mathrm{kg} / \mathrm{m}^{3}$ |
| 15 | 1.033 | 1.37 |
| 15 | 16.033 | 21.21 |
| 15 | 17.033 | 22.54 |
| 15 | 18.033 | 23.86 |
| 15 | 19.033 | 25.18 |
| 15 | 20.033 | 26.51 |
| 15 | 21.033 | 27.83 |
| 20 | 1.033 | 1.34 |
| 20 | 16.033 | 20.85 |
| 20 | 17.033 | 22.15 |
| 20 | 18.033 | 23.45 |
| 20 | 19.033 | 24.75 |
| 20 | 20.033 | 26.06 |
| 20 | 21.033 | 27.36 |
| 35 | 1.033 | 1.28 |
| 35 | 16.033 | 19.84 |
| 35 | 17.033 | 21.08 |
| 35 | 18.033 | 22.31 |
| 35 | 19.033 | 23.55 |
| 35 | 20.033 | 24.79 |
| 35 | 21.033 | 26.02 |
| 40 | 1.033 | 1.26 |
| 40 | 16.033 | 19.52 |
| 40 | 17.033 | 20.74 |
| 40 | 18.033 | 21.96 |
| 40 | 19.033 | 23.17 |
| 40 | 20.033 | 24.39 |
| 40 | 21.033 | 25.61 |
|  |  |  |


| Compressibility Factor, Z |  |  |
| :---: | :---: | :---: |
| Z | Pressure | Temp |
|  | atm | ${ }^{0} \mathrm{C}$ |
| 0.9993 | 1 | 17 |
| 0.9994 | 1 | 27 |
| 0.9995 | 1 | 37 |
| 0.9996 | 1 | 47 |
| 0.994 | 10 | 17 |
| 0.995 | 10 | 27 |
| 0.9959 | 10 | 37 |
| 0.997 | 10 | 47 |
| 0.9773 | 40 | 17 |
| 0.9813 | 40 | 27 |
| 0.9848 | 40 | 37 |
| 0.9879 | 40 | 47 |
| Consider Z equal to | 0.99 |  |

## Material and Type of Construction for LPG Cylinder

LPG cylinders conform to IS 3196 and are manufactured from low carbon steel of welded construction. The steel sheet conforms to IS 6240 /IS 15914 as per the details given below.

S 6240: Hot Rolled Steel Plate (up to 6 mm ) Sheet and Strip for the Manufacture of Low-Pressure Liquefiable Gas Cylinders

Table 1 Chemical Composition (Clauses 6.1 and 6.2) Constituent, Percent

| Grade | Constituent Percent |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Carbon | Manganese | Silicon | Sulphur | Phosphorus | Aluminium |
|  | Max | Min | Max | Max | Max | Min |
| $(0)$ | $(2)$ | $(3)$ | $(4)$ | $(5)$ | $(6)$ | $(7)$ |
| 1 | 0.16 | 0.30 | 0.25 | 0.025 | 0.025 | 0.020 |

NOTES:

1. Elements not listed in this table may not be added intentionally to the steel. All suitable arrangements are to be made to prevent such elements being added from scrap or other materials used during manufacture, which impair the mechanical properties and usability.
2. Steel maybe supplled with the addition of micro-alloying elements like niobium, titanium, and vanadium The micro-alloying elements shall not exceed 0.10 percent when added indwidually or in combination.
3. The niltrogen content of the steel shall not be more than 0009 percent. This has to be ensured by the manufacturer oy occaslonal check analysk.

Please read the detailed White paper :
https://www.tce.co.in/wpcontent/uploads/2021/04/ Meeting-Oxygen-
Demand-Tata-Consulting-Engineers-Response.pdf

Please read the SOP for converting LPG Cylinders to Oxygen:
https://www.tce.co.in/sop-convert-lpg-cylinders/

Table 3 Mechanical Properties（Clauses 7.2 and 8．2．2）

| Tensile Strength MPa | Yield Stress MPa | Percentage Elongation at <br> Gauge Length s．Gs S： | Internal Diameter of Bend |
| :---: | :---: | :---: | :---: |
|  | Min | Min | Max |
| $(1)$ | $(2)$ | $(3)$ | $(4)$ |
| $350-450$ | 240 | 25 | t |

NOTE－Where＇$t$＇is the thickness oftest plece．
IS 15914：High Tensile Strength Flat Rolled Steel Plate（Up To 6 mm ），Sheet and Strip for the Manufacture of Welded Gas Cylinder

Table 1 Chemical Composition（Clauses 5．2，6．1 and 6．2）

|  |  | Constituent，Percent |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| S．No． <br> （1） | Grade (2) | Carbon <br> Max <br> （3） | Manganese <br> Min <br> （4） | Silicon Max （5） | Sulphur Max <br> （6） | Phosphorus <br> Max <br> （7） | Aluminium <br> Min <br> （8） |
| i | HS 235 | 0.16 | 0.30 | 0.25 | 0.025 | 0.025 | 0.015 |
| ii | HS 265 | 0.18 | 0.40 | 0.30 | 0.025 | 0.025 | 0.015 |
| iii | HS 295 | 0.19 | 0.50 | 0.35 | 0.025 | 0.025 | 0.015 |
| iv | HS 345 | 0.20 | 0.70 | 0.45 | 0.025 | 0.025 | 0.015 |

NOTES：
1．Elements not listed in this table may not be added intentionally to the steel．All suitable arrangements are to be made to prevent such elements being added from scrap or other materials used during manufacture，which impair the mechanical properties and usability

2．Steel may be supplied with the addition of micro－alloying elements like niobium，titanium，vanadium and boron．The micro－alloying elements shall not exceed 0.10 percent when added individually or in combination．
3．The nitrogen content of the steel shall not be more than 0.009 percent．This has to be ensured by the manufacturer by occasional check analysis

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## Please read the detailed

 White paper ：https：／／www．tce．co．in／wp－ content／uploads／2021／04／ Meeting－Oxygen－
Demand－Tata－Consulting－ Engineers－Response．pdf

Please read the SOP for converting LPG Cylinders to Oxygen：
https：／／www．tce．co．in／sop－ convert－lpg－cylinders／

| Grade | Constituent Percent |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| S No. | Grade | Tensile Strength Mpa | Yield Stress MPa Min | Percent Elongation at Gauge Length Min |  | Reference Heat <br> Treatment <br> Austenitizing <br> Temperature |
|  |  |  |  | $\begin{gathered} <3 \mathrm{MM} \text { (see } \\ \text { Note } 2 \text { ) } \end{gathered}$ | 3 to 6 mm (see Note 3) |  |
| i | HS 235 | $360-460$ | 235 | 22 | 30 | $920=960$ |
| ii | HS 265 | 410-510 | 265 | 20 | 28 | 890-930 |
| iii | HS 295 | 450-560 | 295 | 18 | 26 | 890-930 |
| iv | HS345 | 490-610 | 345 | 17 | 24 | g80-920 |

## Please read the detailed White paper :

https://www.tce.co.in/wpcontent/uploads/2021/04/ Meeting-Oxygen-Demand-Tata-Consulting-
Engineers-Response.pdf
NOTES:

1. The above properties are specified for flat rolled steel and should meet the properties of normalized (Time at austenitizing temperature
 cylinders. Considering the drop in the normalizing, tensile properties of flat rolled products are to be mutuallyagreed upon between the cylinder manufacturers and steel producers for normallizes cylinders
2. Percentage elongation for products of thickness less than 3 mm , is calculated based on test pleces with a width of 20 mm and a gauge length of 80 mm
3. Percentage elongation for products of thickness 3 to 6 mm , is calculated based on test pleces with a gauge length of $L 0=5.65$, is. is the initial cross-sectional area of the test plece)

Please read the SOP for converting LPG Cylinders to Oxygen:
https://www.tce.co.in/sop-convert-lpg-cylinders/

## For Further Details - Please write to below email IDs

Tata Consulting Engineers
www.tce.co.in
Email: tceconnect@tce.co.in


[^0]:    Nozzle need to be replaced with oxygen service nozzle; modify the threading on oxygen nozzles to match the $\mathrm{CO}_{2}$ extinguisher nozzle - Else in case a CYLINDER BANK is being used - no changes needed. It is recommended to use CYLINDER BANK approach as opposed to individual Cylinders for both safety and time since it will not involve any nozzle changes

